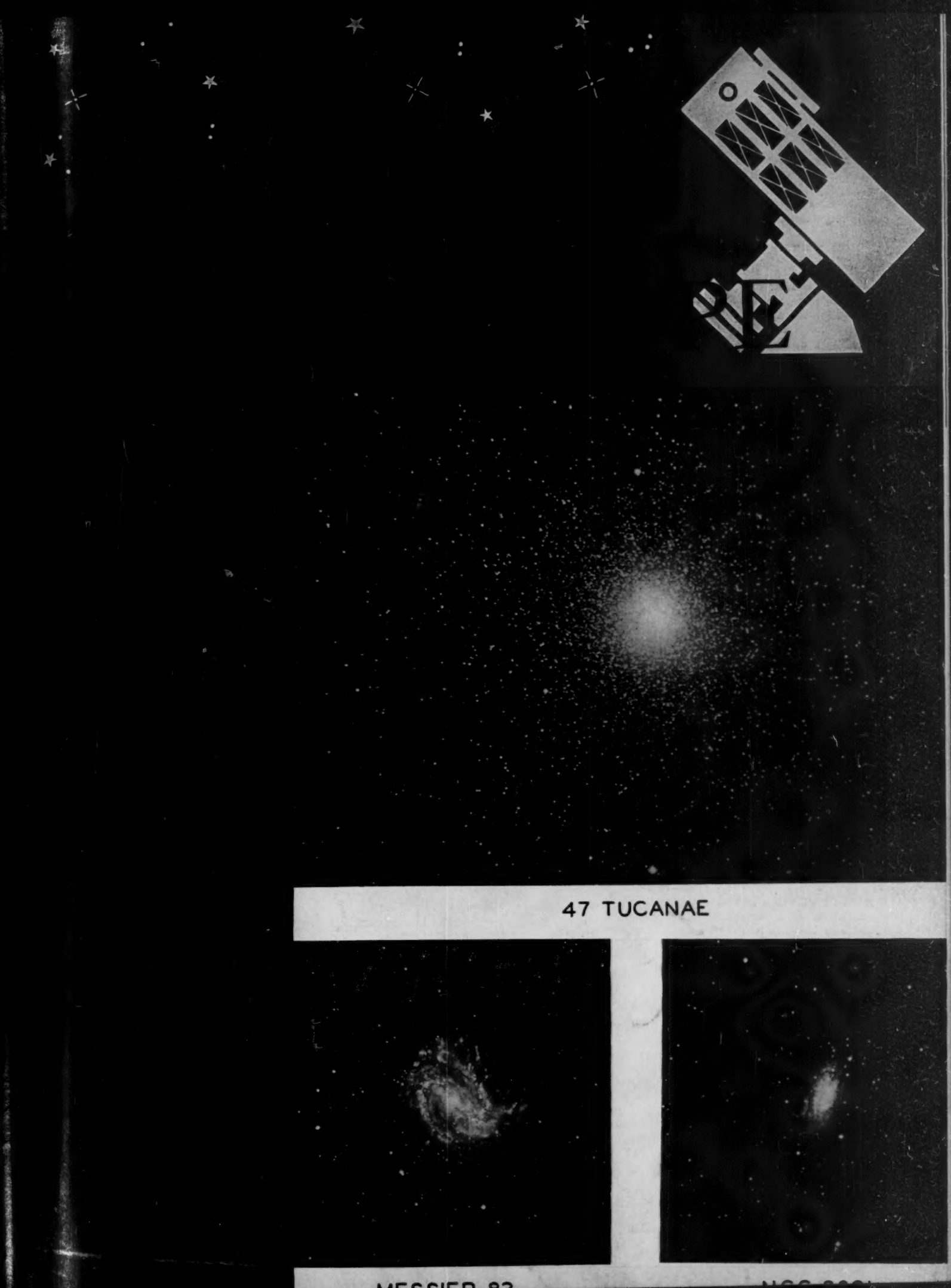

47 TUCANAE

MESSIER 83

NGC 2808

In Focus

THE back-cover photograph of Scutum Sobieski includes the main part of the constellation of Scutum and portions of Aquila, Sagittarius, and Serpens. This shield-shaped mass of stars is one of the most interesting "clouds" of the Milky Way.

In the center of the field is the cluster, Messier 11; the bright star on the left with the halation ring around it is Lambda Aquilae. Eta Scuti can be seen a little to the left and slightly north of (above) M11. To the right and a little north of the cluster are four stars forming a quadrilateral which looks like a distorted bowl of the Big Dipper. The top "pointer" is the semi-regular red variable star, R Scuti. This star ranges from magnitude 5.0 to 9.0 in about 146 days. The 4th-magnitude star, Beta Scuti, is due north of R Scuti.

Until recently the search for variable stars in the Scutum cloud and its vicinity has yielded few variables in the dense shield-shaped mass itself. In the region of 210 square degrees centered on M11, there were 392 stars for which variability had been established. Of these, 127 were found by assistants at the Maria Mitchell Observatory. But only 120 known variables lay in what we regard as the cloud; and of 14 Cepheids in this number, periods are known for four only. The great concentration of stars in the heart of the cloud makes it difficult to obtain periods and light curves from plates taken with the 7½-inch and 10-inch triplet lenses.

But the open scale of plates made with the Bruce 24-inch doublet at Harvard's South African station is revealing an as yet unlimited number of new variables. On 50 plates taken between 1933 and 1938, 974 new variables have been discovered, making the total number now known 1,366.

Since there is as yet no diminution in the number of new variables on successive plates, many more comparisons should be made. It is hoped, from this mass of variables, that periods can be obtained for a sufficient number of classical and cluster-type Cepheids to reveal their distances, and consequently, to allow us to decide whether we are dealing with a galactic cloud or a galactic window. In the first case, the Scutum cloud will really be what its name implies; in the second, it will be merely a portion of the Milky Way which is not obscured by dark nebulosity.

Among the interesting stars in this region is the nova-like variable, CM Aquilae, discovered by Margaret Walton Mayall in 1925. A mild outburst in 1914, when it rose to magnitude 15.2, was followed by a fairly fast return to 16.4; in 1925, it became as bright as 14.3, and then decreased rapidly. In June, 1934, there was a typical nova outburst. The star increased in brightness by three magnitudes to 13.2; in November, 1940, it was still decreasing slowly, at magnitude 15.5.

MARGARET HARWOOD
Maria Mitchell Observatory

Sky and TELESCOPE

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The Editors Note . . .

THAT astronomy, long looked upon as a pure research science for professionals or as an "escape" science for amateurs, plays an important role in this war.

That even professional astronomers are having to go out and learn the stars, in order to show their navigation students where to find them.

That our planetariums, often thought to be too publicity-minded, are proving their usefulness by teaching large groups of Army and Navy men just what the astronomical triangle really is, and how to find the stars.

That in spite of Rude's and other commendable star finders, the cry of air and sea navigators alike is strongly: How can we identify the stars?

That, like finding one's way through the woods at night without a light, or predicting the weather from local observations, knowing the constellations has been until now an almost lost art, the value of which is suddenly apparent just when such simple things might seem unimportant.

That scores of men ordinarily employed in observatory work and in teaching astronomy have gone to Washington or elsewhere for the duration, and in every case for scientific duty.

That other scores are teaching navigation to enormous classes attended by undergraduates, service men, and civil air pilots; while most college introductory astronomy courses are being revised to contain largely "practical astronomy" and constellation study.

In all these things, amateur astronomers really have the edge. A good amateur of long experience knows the stars so well he can identify them under any conditions. He is probably adept at simple mathematics. He knows some optics, and how to make optical surfaces; possibly, also, he has learned some machine work. He knows how to operate an instrument, and has a practiced observing eye.

WANTED: For a dozen jobs in this war—professional and amateur astronomers.

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COVER: The globular cluster 47 Tucanae (N.G.C. 104) lies near the Small Magellanic Cloud. It is one of the nearest and brightest of the globulars. The exposure time was 60 minutes; scale 11″.5 to 1 mm., enlarged 2.25 times. The spiral nebula M83 (N.G.C. 5236) is one of the brightest in the southern sky. The exposure is here 90 minutes; scale 12″.4 to 1 mm. N.G.C. 3621 is a peculiar spiral with a wide, faint extension to the southward which nearly doubles its length compared to that clearly seen in the reproduction. The exposure is 80 minutes; scale 11″.6 to 1 mm. Engraving from H. C. O. *Tercentenary Papers*, No. 12; photographs taken with the 60-inch at Bloemfontein.

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The Starry Heavens in July 22

BACK COVER: Plate made July 4, 1927, centered on M11 in the Scutum star cloud. Exposure, 3 hours, with the 7½-inch Cooke triplet telescope of the Maria Mitchell Observatory, Nantucket, Mass.

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Astronomers Meet at New Haven

By Victor Goedicke
Yale University Observatory

MANY midwestern astronomers received their first acquaintance with the dimout at the 68th meeting of the American Astronomical Society in New Haven; those who ventured to bring their cars received an introduction to gas rationing as well. In spite of these difficulties the meeting was well attended.

The sessions were held in the large and comfortable auditorium of the Sterling Law Buildings. At the teachers' conference on Friday morning many members gathered to discuss the topical subject, "The Teaching of Navigation." This stimulating and lively session began with papers by Drs. John Q. Stewart and Newton L. Pierce, after which there was discussion from the floor by Lt.-Comdr. H. O'D. Hunter, U.S.N. (Ret.), of the Yale naval science department, Col. George W. Mixter, author of *Primer of Navigation*, and Prof. F. W. Keator, of the Yale mechanical engineering department.

In his introductory remarks, Dr. Stewart commented upon the services being rendered by scientists today, and expressed the hope that their efforts would not be nullified by inadequate leadership on the part of world political strategists. Going on to practical problems in the teaching of navigation, he offered five recommendations as a basis for discussion: First, universities should restrict the scope of their efforts, and attempt to provide careful and thorough basic training rather than to cover superficially the whole of navigation. Second, marine and air navigation should be presented together in a unified course. Third, preliminary courses in trigonometry and logarithms should not be required; time is too short for the amount of theoretical background which astronomers have included in the past. Fourth, terminology in navigation should be standardized. Fifth, a course in navigation should contain divisions in piloting, dead reckoning, radio aids to navigation, celestial navigation, sailings, and problems of relative motion.

Dr. Pierce followed Dr. Stewart with suggestions derived from the Princeton courses in navigation, stressing especially the need for providing extensive practice in problems of relative motion, with applications in interception and in operations from a moving base. Dr. Pierce recommended the assignment of many problems, and believes that they should not be made too easy.

In the informal speeches and discussion which followed, there was much divergence of opinion in details, but on several important points there was a fair degree of unanimity. Everyone agreed that college students in general, and especially those not in scientific or mechanical studies, are so poorly prepared in mathematics (and even arithmetic) that many are certain to fail as navigators unless they are given extensive drill in all computational procedures. Lt.-Comdr. Hunter's comment was particularly heartfelt: "With all due respect to liberal arts students, they are able to talk themselves around any situation—and can't add two and two." Prof. Keator commented that most students are accustomed to assimilate information piecemeal, and to discard each piece as soon as it has been recited upon. There were many seconds to both of these comments.

The problem of the proper amount of theory to be included in navigation courses provoked a lively and extended discussion. It was generally agreed that the objective of a liberal arts course, aimed at providing an understanding of the theory of navigation, is necessarily different from that of the emergency courses now needed, and that the latter require a smaller amount of theory. However, opinion differed widely upon the extent to which the theory should be reduced. Perhaps the most extreme view was represented by Dr. H. T. Stetson, who expressed the opinion that there is no more reason for a student to derive the formulae upon which navigation is based than there is for a computer at the Naval Observatory to derive by power series each logarithm which he uses.

Several speakers commented upon the need for avoiding the abstract quality of angles on the celestial sphere when dealing with students who have not studied astronomy. Col. Mixter recommended that the astronomical triangle be presented as a triangle on the surface of the earth, connecting the subsolar point,

Members and guests at the 68th meeting of the American Astronomical Society, New Haven, June 12-14, 1942. Photo by Samuel Kravitt.

the observer, and the pole; other members of the audience supported this and similar suggestions. The session ended with the feeling that the value of such conferences had been reaffirmed.

The first formal session took place on Friday afternoon, when Dean Charles H. Warren welcomed the society on behalf of Yale. President Joel Stebbins replied briefly for the society, and opened the session for papers. Among the interesting papers of this session was the eighth, by Miss Ida Barney, in which was described the voluminous task of deriving proper motions for the Yale photographic zones between $-20°$ and $-30°$ of declination. By comparing the Yale photographic positions with those given in the *Astronomische Gesellschaft* catalogue of 40 years earlier, Miss Barney has derived proper motions of about 27,000 stars, more than 20,000 of which are stars whose proper motions have never before been determined. Miss Barney estimates that almost all of the derived proper motions are sufficiently large to be considered certainly real, and that there are about 150 newly discovered stars of large proper motion (larger than 0.2 seconds of arc in one coordinate) in the group. The greatest difficulty, she said, was in evaluating and eliminating the magnitude errors in the older catalogue.

In another of the afternoon papers, Dr. Peter van de Kamp, of Sproul Observatory, pointed out the necessity for looking into the future in selecting comparison stars for studying stars of large proper motion. In a world with so unpredictable a future as ours, it was refreshing to hear Dr. van de Kamp speak of research plans extending to the year 2200.

The scheduled tea came at the end of a hot afternoon, and it was with relief that the members found they were not to be served tea, but lemonade. The lounge of the Sterling Law Buildings is very comfortable and the tea was a pleasant function.

Leaders in the navigation discussion, with President Joel Stebbins (left) and Dr. Dirk Brouwer (third on left), were (left to right): Dr. Stewart, Col. Mixter, Lt.-Comdr. Hunter, Dr. Eckert, and Dr. Pierce.

In the evening lecture, by Dr. W. J. Eckert, director of the Nautical Almanac Office, the audience learned that the current *American Air Almanac* is by no means the first one. A number of earlier almanacs designed primarily for navigation were described, and samples from several were shown in lantern slides. Finally, the audience listened with great interest and not a little envy as Dr. Eckert described his punched card method of mechanical proofreading, which reduces errors to the vanishing point.

The Saturday sessions contained many interesting papers, among which was a report by Dr. Arthur Adel, from Lowell Observatory, of the discovery of a new spectral region in the infrared in which the earth's atmosphere is transparent. Until Dr. Adel's work, the usable solar spectrum was limited by an absorption band of carbon dioxide at a wave length of 14,000 angstroms, and nothing was known of the spectrum beyond this point. By using a prism of potassium bromide, lent by Dr. C. G. Abbot, of the Smithsonian Institution, Dr. Adel was able to demonstrate the existence of a transparent region beyond this band extending to 24,000 angstroms. This extended the usable solar spectrum by 10 microns, or about 25 times the extent of the wave-length region to which the eye is sensitive.

Following a report by Drs. A. McKellar and W. H. Stillwell, of Dominion Astrophysical Observatory, on the probable presence of lithium in all *R* and *N* stars, Dr. Harlow Shapley commented upon the importance of this discovery in the theory of energy generation in the giant stars. Among the comments which followed was one by Dr. Lyman Spitzer to the effect that the abundance of an element on the surface of a star may have no relation to its abundance at the center, where the energy generation takes place.

Further studies of the variables in the Scutum star cloud were reported by Margaret Harwood, of Maria Mitchell Observatory. (See back-cover photograph and "In Focus.")

On Saturday afternoon, many members enjoyed a tour around the Yale campus, which they found attractive in spite of occasional sandbag barricades around vulnerable areas. In the evening the society undertook the 5-mile trip to Savin Rock for the banquet, most members choosing to go by trolley rather than to drive their cars along the shore with headlamps extinguished. After a splendid dinner, the members had the privilege of hearing from Prof. William Lyon Phelps, who spoke about the 1882 transit of Venus; from Mrs. Cecilia Payne-Gaposchkin, who spoke movingly of the devotion of the Mexican people to their new observatory; from Dr. D'E. Atkinson, whose descriptions of bomb removal work in England were thoroughly enjoyed; and from Dr. Keivin Burns, who spoke of his work and associates of earlier years. Dr. Stebbins was, as always, an incomparable toastmaster.

Unofficially, a most enjoyable portion of the program, for some more enthusiastic members, was the time spent at Savin Rock Amusement Park Saturday night.

On Sunday, following an open house at the observatory, the society had a picnic lunch on the observatory grounds. The cloudy sky made for comfortable coolness, and the inevitable rain held off until the lunch was completed, then came down in torrents. There followed, on the invitation of Dr. Frederick Slocum, an excursion to Middletown, Conn., where everyone enjoyed seeing again the Van Vleck Observatory, with its delightful exterior and its neat and well-planned interior. Tea, served in the library, brought the meeting to a close.

The catalogue camera at Yale Observatory, photographed November 12, 1941, by the author.

Here Gamma Cassiopeiae appears the brightest star in the famous W, although this picture was taken in October, 1941. It is a B-type star (blue-white) and photographs better than Alpha, which is a K star of magnitude 2.47. Beta is F5, 2.42; Delta is A5, 2.80; Epsilon is B5, 3.44; Kappa is B0, 4.24. Note the Double Cluster in Perseus at extreme left.

THE STORY OF GAMMA CASSIOPEIAE

By Ralph B. Baldwin

Dearborn Observatory, Northwestern University

STARS are in many ways like people. Some persons get famous for doing one thing once; others for doing something else many times over; others for never doing the same thing the same way twice. New stars flare up and subside, apparently only once in a lifetime; Cepheid variables pulsate regularly; stars like Gamma Cassiopeiae are full of surprises.

Prior to 1927, this star was inactive. It was often referred to as a typical *B*nne star. The "e" signifies emission lines in its spectrum and the "nn" means that the lines are extremely wide. But after 1927 practically every physical parameter of this star was variable, and the sequence of the variations unpredictable.

Gamma Cassiopeiae really gained "notoriety" in 1936, when Baize in France and Cherrington in the United States announced that the star in the middle of the familiar W of Cassiopeia was nearly twice as bright as normal. Although for nine years before, intricate spectroscopic changes had been observed, no measures of brightness or temperature has been made. But as Gamma became nearly a 1st-magnitude star, it immediately was placed on numerous photometric and spectrophotometric observing lists, where it remains to this day. It is also still of interest to amateurs and those who a few years ago noticed the strange appearance of Cassiopeia's W and wonder if Gamma may be expected to flare again.

But to return to the beginning—actually the pre-1927 spectrum of Gamma Cass (as astronomers usually call it) was quite complicated. It consisted of a continuous spectrum crossed by numerous, very broad, weak absorption lines. These were identified with the usual lines present in *B*0 absorption-line stars by R. H. Curtiss. Very slightly to the red of the absorption-line center was a broad emission line. This, in turn, was bisected by an absorption line, leaving two approximately equal emission components. Emission lines appeared only at the strongest absorption lines.

The interpretation of this complex line structure is now well understood.[1] The broad absorption line is found on microphotometer tracings to be dish-shaped. It is produced in a normal reversing layer close to the star's photosphere ("surface") and is widened by the rapid rotation of the star. The rotational velocity is of the order of 300 kilometers per second.

The emission line is produced in a tremendously extensive atmosphere rotating with a velocity which decreases with increasing height above the photosphere. In this manner, the relative widths of the emission and absorption lines are suitably explained. The central reversal of the emission lines comes from absorption by high-level atoms whose rotation is slow because of the conservation of angular momentum. Moreover, the speed of rotation does not enter into the problem of the origin of these central absorption lines as the line (in each case) is in the normal position—the rotational motion of the affected atoms is transverse to the line of sight and they thus produce an undisplaced absorption line.

With this picture of the basic structure of Gamma Cass we may build up an approximate physical model of the star.

No adequate trigonometric parallax is available, so the distance must be determined by an indirect method. Weak interstellar H and K lines of CaII (ionized calcium) are present, and with allowance for the thickness and density of the interstellar CaII clouds in the direction of Cassiopeia, a distance of about 100 parsecs (325 light-years) is found. Since the normal apparent magnitude of Gamma Cass before 1928 was +2.25, its absolute magnitude then was about —2.75. A compilation of all available data gives —2.5 as the best determination.

The temperature of this star during its inactive stage was probably constant. From its color, this temperature was found by observers in Greenwich, England, and Madison, Wis., to be 13,500° K, when adjusted to the color-temperature zero point of R. C. Williams. From this may be calculated[2] the radius of the star, and it turns out to be about 8.3 times that of the sun.

The absolute magnitude of —2.5 corresponds to a mass 12 times the sun's, and thus the mean density of Gamma Cass is about 1/50 the sun's, or 0.0281 times that of water.

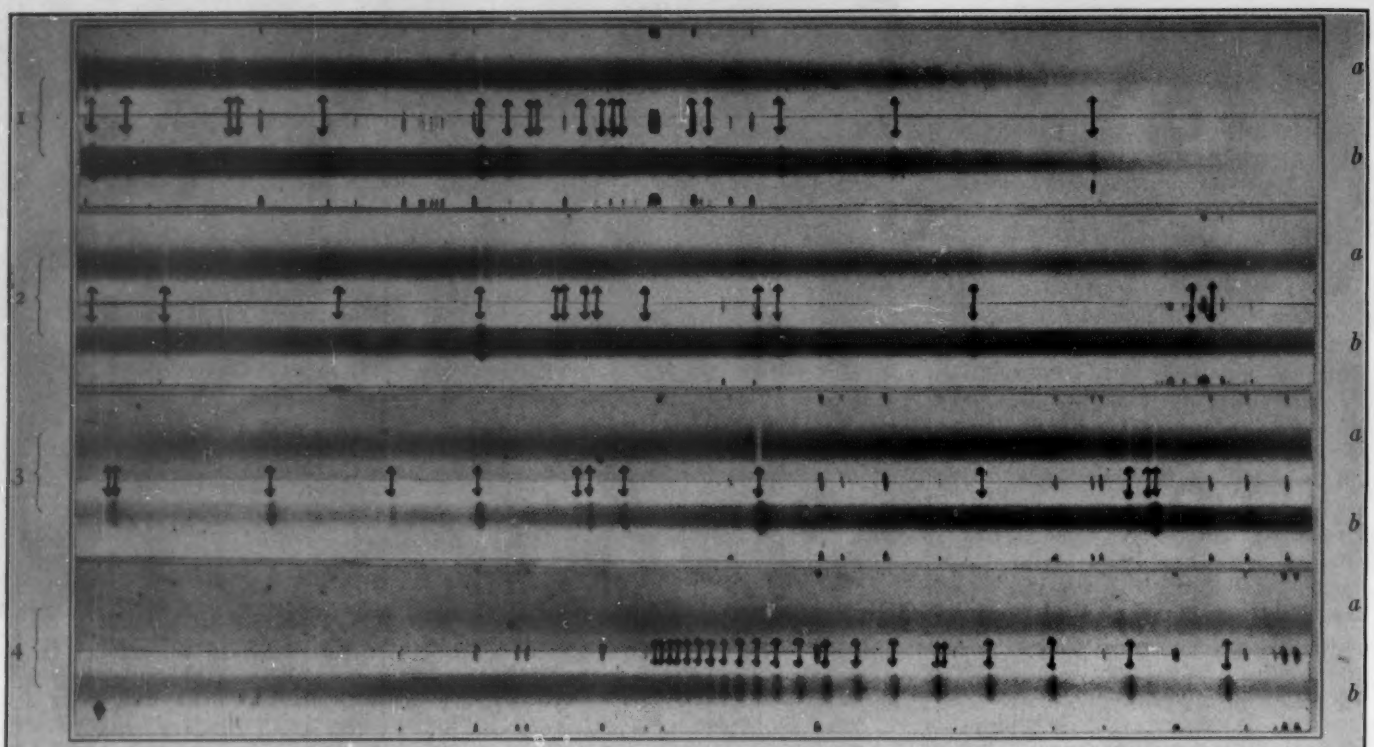
The emission lines in this period were about 40 per cent as wide as the absorption lines, and if the law of conservation of angular momentum were obeyed, the emitting layers in the atmosphere were at least 2.5 radii of the photosphere in height. The outer layers extended to an unknown altitude.

This then, in brief, is the picture of the physical nature of Gamma Cassiopeiae prior to 1927.

Spectrograms taken since that time

[1] Ed. Note: The reader may want to review these more elementary discussions: *Sky and Telescope*, March, 1942, "The Story of Beta Lyrae"; *Sky and Telescope*, May, 1942, "The Diagnosis of Stars from Their Spectra," and "High-Dispersion Spectra."

[2] Use $\log R = \frac{5{,}900}{T} - 0.20\ M_v - 0.02$



THE SPECTRUM OF γ CASSIOPEIAE

The lines in the four sections are, from right to left:

a) March 28, 1936; *b*) September 22, 1937.

SECTION 1: *He* I 4713, *Fe* II 4629, *Fe* II 4584, *Fe* II 4556, *Fe* II 4549, *Fe* II 4522, *Fe* II 4520, *Fe* II 4515, *Fe* II 4508, *Fe* II 4491, *Fe* II 4489, *Mg* II 4481, *He* I 4472, *Fe* II 4417, *He* I 4388, *Fe* II 4385, *Fe* II 4352, *Hγ*

SEC. 2: *Fe* II 4303, *Fe* II 4297, *Fe* II 4233, *Fe* II 4179, *Fe* II 4173, *He* I 4144, *Si* II 4131, *Si* II 4128, *Fe* II 4123, *He* I 4121, *Hδ*, *Ni* II 4067, *He* I 4026, *He* I 4009

SEC. 3: *Hε*, *Ca* II 3968, *He* I 3965, *Ca* II 3933, *Hζ*–*He* I 3889, *Si* II 3863, *Si* II 3856, *Si* II 3854, *Hη*, *He* I 3820, *Hθ*, *Hι*, *Ni* II 3769

SEC. 4: *Hκ*, *Hλ*, *Hμ*, *Hν*, *He* I 3705, *Hξ*, *Ho*, *Hπ*, *Hρ*, *Hσ*, *Hτ*, *Hυ*, *Hφ*, *Hχ*, *Hψ*, *Hω*, *H*27, *H*28, *H*29, *H*30, *H*31, Hydrogen continuum

Courtesy, "The Astrophysical Journal."

show that tremendous and continuous changes have occurred. Many of these are of such complexity that they are not yet well understood.

The two emission components of all lines were essentially equal from at least 1911 to 1927. If V equals the estimated intensity of the violet emission component, and R that for the red component, the ratio V/R is unity for equality of intensity of the two.

In 1927, the V/R ratio became slightly greater than unity, that is, the violet emission component was then stronger than the red. The relative intensities returned to normal, or perhaps even became reversed, during 1928 and 1929, and from this time on the amplitude of the V/R curve increased in subsequent cycles. There have been four such cycles altogether, and V/R was greater than unity in 1927, 1930, 1933, and 1937. Possibly another cycle had begun by 1940, but the rapid fading of emission lines which occurred then made measurement of the V/R ratio difficult.

The cause of these changes is not established and no suitable mechanism has been suggested.

Other spectral changes are correlated with the V/R curve. The separation of the emission components has not been constant. They approached and blended in 1934 and 1937, and in both cases the V/R ratio was greater than unity and still increasing as the emission narrowed. V/R was always less than unity during the stages when the emission components separated.

The total intensity of emission relative to the continuous spectrum reached maxima during the single-line stages of 1934 and 1937 (when the emission components had coalesced). After the second maximum, the emission continually weakened, until late 1941 and early 1942 the only remaining emission lines were traces at Hα and Hβ (hydrogen Balmer lines).

Another strange type of spectral change has occurred three separate times. In 1933, before the first single-line stage, the absorption lines between the emission components of hydrogen became slightly stronger and then faded to normal. In 1936, in the corresponding place before the 1937 single-line stage, the central absorption lines of hydrogen and helium were very much stronger for a few months. In 1940, another sharp absorption-line stage occurred and the lines were stronger than ever. Numerous FeIII (doubly ionized iron) lines appeared in addition to those of hydrogen and helium.

Absorption lines of this kind are produced in the outer layers of the stellar atmosphere. They form what is often called a shell spectrum, characterized by unusual relative line intensities. Under conditions of dilute radiation, such as obtain in outer atmospheric shells, absorption lines arising from "metastable" lower levels are unduly strengthened relative to ordinary lines of the same atom.

Comparison of measurements of absorption strengths of both types of lines in the helium spectrum showed that the shell layers were at a height of approximately three times the photospheric radius in both absorption-line stages.

The problem is complicated by the sudden variations in light. The photoelectric light curve by Huffer and a visual light curve (which is the mean of the A.A.V.S.O. light curve and one by the author) are shown in the accompanying chart. There was a continual rise in brilliance for nearly a year, reaching magnitude 1.57 in May, 1937. First-magnitude stars are usually considered to be those brighter than 1.50, so Gamma Cass had become quite conspicuous and the appearance of the constellation was distinctly altered.

However, color temperatures derived at various observatories told us the astounding fact that Gamma Cass grew brighter and cooler at the same time. The color temperature was 11,000° K to 12,000° K in late 1936 and early 1937,

but dropped to about 8,500° K at maximum light.

The only logical explanation for this phenomenon so far apparent is that the star released more energy, thereby becoming brighter, but in doing so, expanded to such an extent that the amount of radiation per unit of surface area decreased.

After this brightness maximum, the light curve fell rapidly and both light and heat reached simultaneous minima at magnitude 2.44 and 8,000° K, respectively. The visual light curve has shown no sudden major variations since that time. The brightness gradually dropped to magnitude 2.95 and then came slowly back to 2.70, where it remains today (June, 1942). Its original brightness, magnitude 2.25, was about one and one half times greater. The ratio of its maximum light (1.57) to its minimum (2.95) is over three and a half times.

The color temperature was far more variable. From a minimum of 8,000° K, it rose to about 11,500° K in 1938, dropped to approximately 9,500° K in 1939, and then skyrocketed to over 30,000° K in 1940. Changes since then are not known, but indications are that the color temperature is again below 20,000° K.

As *Sky and Telescope* readers may know, it is comparatively simple for astronomers to calculate the sizes and densities of ordinary stars such as the sun, Capella, Sirius, and even of its tremendously dense white-dwarf companion. These stars are relatively stable, and fit easily into the usual picture of a star as a tremendous mass of hot gas which radiates energy according to certain mathematically derived laws. These are called "black-body laws," because they are based on the idea that a completely black body (when cold) is a perfect radiator when heated to incandescence. Stars are more or less black-body radiators, and it is this which makes it possible to apply the black-body laws to them.

According to these laws, the color of a star depends upon its temperature, as does also the total amount of energy it radiates per unit of its surface area. If the star is radiating like a black body, we may assume that the temperature determined from its color is proportional to its *effective temperature*, which is the temperature a similarly radiating black body would have. But this is all in turn related to the total brightness, or luminosity, of the star, because that also depends upon the effective temperature. (Luminosity is proportional to the product of energy per unit area and the total surface area of the star.)

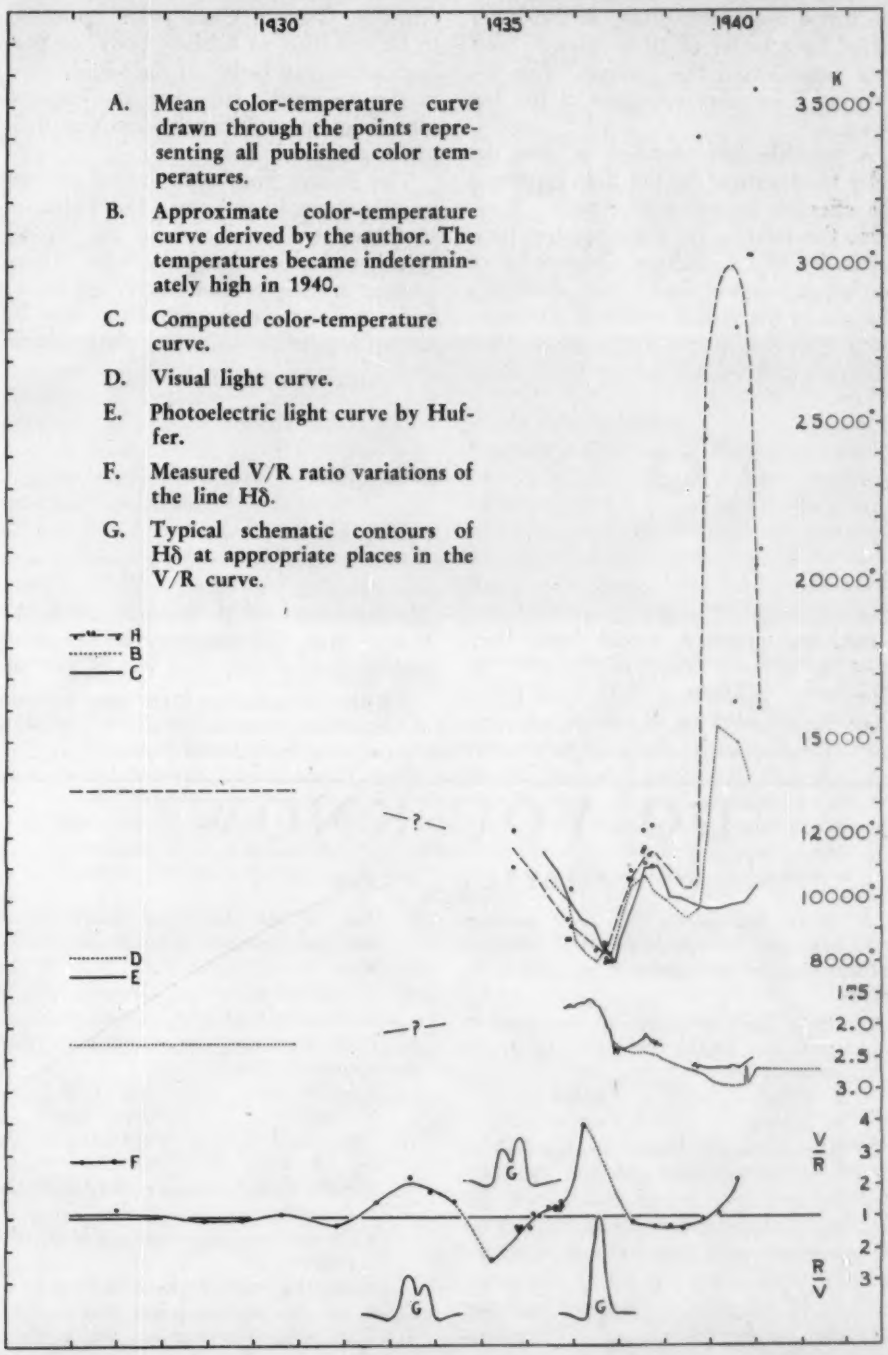
Thus, if the radius of the star could be determined, the temperature might be computed by substituting radius and absolute magnitude in the log R formula[2] and solving. The original absolute magnitude was established as −2.5 when the apparent magnitude was +2.25. The light curve then allows a determination of the absolute magnitude for all dates since 1936.

By this means, the original color temperature of 13,500° K and absolute magnitude of −2.5 yielded a radius of the star's photosphere of 8.3 times the sun's.

Variations of the radius were inferred because the rotationally broadened absorption lines changed in width synchronously with the emission lines.

Hence, with the knowledge of the original radius and the two assumptions that variations in line widths are caused by changes in rotational velocity, and that the law of conservation of angular momentum (radius × velocity = constant) is obeyed, the radius of Gamma Cassiopeiae may be determined for each date on which a spectrogram is available. It varied from an original 8.3 times the sun to 15.5 in 1934, 10.6 in 1936, 18.0 in 1937, and 9.8 in 1939.

With each value of the radius and absolute magnitude, the temperature may be computed for the given date. For 1,200 days from 1936 to 1939 this method yielded temperatures which agreed within the errors of measurement with the observed color temperatures. Only in 1940 and 1941, when the color temperature soared over 30,000° K, did it break down. No comparable rise in temperature was computed. In order that the high color temperature and low luminosity of Gamma Cassiopeiae at that time be correlated, the radius must have shrunk to about 3.5 the sun's. This appears improbable as the emission lines were only slightly wider than normal in-



A. Mean color-temperature curve drawn through the points representing all published color temperatures.

B. Approximate color-temperature curve derived by the author. The temperatures became indeterminately high in 1940.

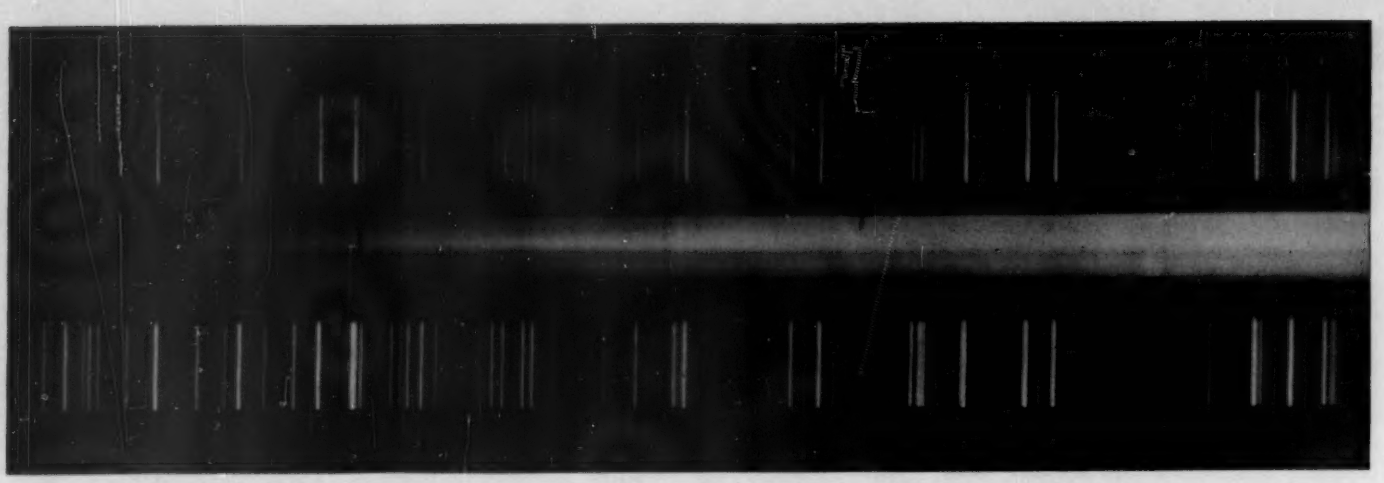
C. Computed color-temperature curve.

D. Visual light curve.

E. Photoelectric light curve by Huffer.

F. Measured V/R ratio variations of the line Hδ.

G. Typical schematic contours of Hδ at appropriate places in the V/R curve.



A portion of the spectrum of Gamma Cassiopeiae taken on June 25, 1936, at Dunlap Observatory. It shows the sharp absorption lines which are produced in the outer atmospheric layers, and the emission lines which arise in the intermediate layers.

stead of three times as wide. It was deemed best to use emission-line widths for this problem, rather than those of the broad absorption lines, as the latter varied by a factor of 10 in intensity and thus complicated the picture. The absorption lines were strongest at the hot phase.

A possible interpretation is that the color temperature did not then represent the effective temperature closely. However, the relative color-temperature gradients by W. A. Hiltner (University of Michigan, unpublished) are absolutely straight in the visible region of the spectrum, and this means that Gamma Cass was radiating as a black body in those colors.

This star furnished a good test of the relative accuracy of the color-temperature zero points as established at Greenwich and Ann Arbor. The highest color temperatures found by Hiltner were over 35,000° K on the Ann Arbor scale of Williams. This corresponds to a gradient of 0.73. With the Greenwich zero point, the gradient would have been 0.54, or a temperature of 200,000° K. The latter gradient is only 0.04 larger than the gradient for an infinite temperature. Consequently, the Ann Arbor zero point appears to be considerably closer to the truth.

Throughout all the temperature changes, Gamma Cassiopeiae appeared to be radiating as a black body, or perhaps as a gray body[3] in the visible part of the spectrum. However, the extreme ultraviolet spectral distribution was definitely not black body.

The Balmer lines of hydrogen are unusually strong in emission. This indicates that they are produced by the recombination of protons and electrons. These protons and electrons formerly existed as hydrogen atoms and were dissociated by absorption of continuous photospheric wave lengths shorter than the limit of the Lyman series (hydrogen ultraviolet). Part of this absorbed energy reappears as emission lines in the various hydrogen series. Only a certain maximum proportion of the energy is converted into the Balmer lines.

Measures were made on spectrograms taken during the 1937 single-line stage. The total amount of energy in all of the Balmer lines was determined. The color temperature at this time was 8,000° K. Assuming black-body radiation, the total amount of energy of shorter wave length than the Lyman limit was computed. It turned out to be considerably less than the observed energy in the Balmer emission lines. Hence, the necessary conclusion is that although Gamma Cass appears to radiate as a black body in visible light, it deviates widely in the inaccessible regions of the spectrum, in the sense of showing an ultraviolet excess.

The above measurements and conclusions were made by the author and have not heretofore appeared in print.

This picture of Gamma Cassiopeiae admittedly is incomplete. Some of the changes which have been observed to occur do not, as yet, have interpretations. In other cases, the suggested model may prove inadequate or completely erroneous. The establishment of a general model of a star whose every physical parameter except mass fluctuates is obviously no easy task. It may take generations of astronomers.

Once the star was quiescent, inactive; then it went through wild changes. Today it has again settled down to a dull mediocrity; it appears essentially as a normal *B* star. Tomorrow—who knows?

[3] When the radiation is the same fraction of black-body intensity for all wave lengths, the radiating body is called *gray*.

DO YOU KNOW?

By L. J. Lafleur

I. Score five points for each question answered, and one point for each question where you do not attempt to select the answer.

1. On a July evening in the northern states you would not expect to see the constellation
   a. Virgo c. Taurus
   b. Libra d. Cepheus
2. Kapteyn is best known for his work on
   a. stellar evolution c. binary systems
   b. cosmogony d. star streaming
3. In Fitzgerald contraction, length in motion equals length at rest multiplied by
   a. $2\pi^2$ c. $\sqrt{1 - \frac{v^2}{c^2}}$
   b. $\sqrt{\frac{l}{g}}$ d. l^2
4. One of the following constellations does not contain part of the Milky Way:
   a. Ophiuchus c. Cygnus
   b. Vulpecula d. Virgo
5. There is at least one star brighter than magnitude 3.0 in
   a. Delphinus c. Sagittarius
   b. Aquarius d. Capricornus
6. The vernal equinox is the place in the sky where the sun is
   a. its extreme distance south of the equator
   b. its extreme distance north of the equator
   c. on the equator going north
   d. on the equator going south
7. The polar diameter of the earth is about
   a. 7,800 miles c. 7,950 miles
   b. 7,900 miles d. 8,000 miles
8. The number of angstrom units in a centimeter is
   a. 10,000 c. 10,000,000
   b. 1,000,000 d. 100.000.000

II. Each of the following figures is important in astronomy. Can you identify them? Count five points for each.

a. 7,926 c. 1° 35′ e. 186.271
b. 88 d. −273° f. 3.258

III. Count 15 points for each question correctly answered.

1. If the amount of matter in the universe were infinite, and distributed more or less evenly throughout infinite space, Newton's law of gravitation could not be valid. Why is this statement true?
2. What are the forces other than pressure acting upon a mass situated in the earth's equatorial plane and four miles from the center of gravity?

(Answers on page 20)

FACTS ABOUT THE SUN

By William H. Barton, Jr.

In July, northern hemisphere inhabitants are keenly aware of the sun, but not many know how its distance is measured and how it moves. These and other problems are discussed here and in the Hayden Planetarium this month.

IT is impossible to say when the sun was discovered. It seems to have been known always. The most primitive man must have been attracted to this bright body moving across his sky. Dogs bay at the moon. The cock crows to the rising sun. However, seeing may be believing, but it is not necessarily understanding.

Many ancient peoples worshiped the sun. The ancient Persians had a sun chariot traveling across the sky and they sacrificed horses to it. The Greeks worshiped the sun under the name of Helios, but they paid very little attention to him. One of the complaints against Socrates was that he did not believe in the divinity of the sun and moon, and that he contaminated Athenian youth with the doctrine that the sun was a stone and the moon, earth. The Roman worship of the sun was even milder than the Greek. But we still have our sun worshipers, who sit in parks, or lie on beaches, with upturned faces, receiving the beneficent rays of the sun.

The motion of the sun was man's first clock and calendar. It governed his life; why should he not worship it? It was also his source of illumination. When the sun set and darkness came, he went to bed, to arise with its rising the next morning. Its places of rising and setting told him of the changing seasons. Its shadow across the dial measured the hours of his day. Only comparatively recently has man seriously asked questions about the sun, some of which are still engrossing the scientists of today. What is the sun made of? What keeps its heat up? Why does it move across the sky? Why does it sometimes dim out at midday? These are just a few such questions.

For instance, let us consider the sun's distance. The ancients speculated upon it, but there was no means of measuring it. Tycho Brahe estimated the sun's distance as 1,150 radii of the earth, or 20 times the moon's distance. This would amount to about four and a half million miles, and no one at that time could offer a more accurate figure. Kepler, from his studies of Tycho's observations on Mars, thought the parallax[1] of the sun was not more than one minute of arc, corresponding to a distance of at least 13½ million miles. These, and others too, were rather poor determinations, for Flamsteed, some time later, stretched the figure to 81,700,000 miles.

The first acceptable value was obtained as a result of a suggestion made by Edmond Halley, of comet fame. In 1716, when he was nearly 60 years old, he published a paper in the *Philosophical Transactions* of the Royal Society of London, in which he suggested using the planet Venus in transit across the sun's disk to find the solar parallax. He had no chance of making the observations himself, but generously bequeathed the job to posterity. Transits of Venus are rare astronomical events. Halley knew that the next pair would occur in 1761 and 1769.

The method used was essentially the observing of the planet from two distant stations on the earth simultaneously, and by triangulation working out the planet's distance in somewhat the manner used in surveying or in artillery range finding.

As a result of the observations made on these occasions, especially the 1769 transit, a more definite value of the sun's distance was obtained. The result—95½ million miles—is said by Astronomer Royal Airy, in his Ipswich lectures of 1848, "to be so far accurate that there is no probability of an error of half a million miles"!

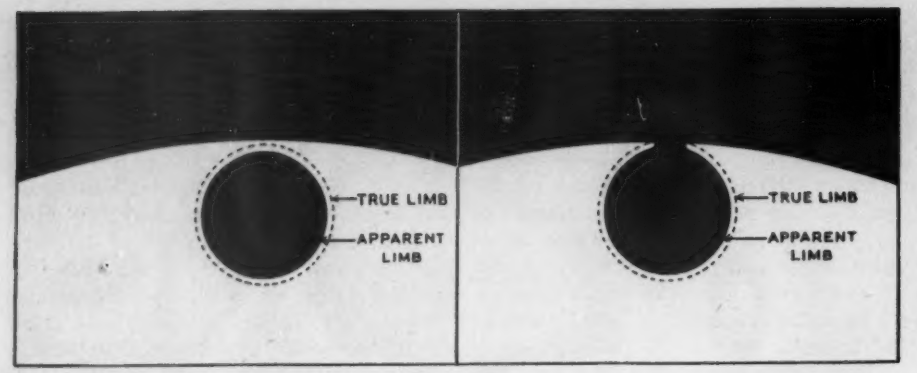
As a matter of fact, values obtained from the 1761 transit varied from 76 to about 96 million miles, according to Richard Proctor. The 1769 values were between 92 and 96 million. Encke, in 1824, published the results of a laborious analysis of the observations of 1769, and found 95,274,000 miles as the most probable value. This value stood until 1854, when Hansen announced that the distance was about four million less. Then it was found that Encke had much overestimated the worth of the 1769 observations. Powalky, in 1864, reworked the problem and found 92 million as the "correct" value, only to have Stone, then first assistant at Greenwich, drop it to 91,840,000. Newcomb differed from both Encke and Stone. It was shown that the observations of 1769 were very poor and gave values anywhere from 90 to 97 million miles.

When a transit of Venus occurs, the moment of contact depends upon the observer's position on the earth. Thus, when Venus is at A, it appears to an observer at C to be at the sun's edge. However, the observer at D does not see Venus contact the sun until the planet has moved to B. The angle (or proportion of its orbit) traversed by Venus in this interval is known, and, neglecting the earth's rotation (which can be easily accounted for), the line joining D and C clearly makes the same angle at E as does the line A-B. The actual distance C-D is known, so the angle subtended at the sun by the radius of the earth can be computed. This is called the sun's geocentric parallax, and is inversely proportional to the sun's distance. All diagrams in this article are from "Splendour of the Heavens."

The 1761 transit was visible from most of Europe and observations could be made from many stations there. But posts had to be established in other parts of the world. One was in St. Helena and another at the Cape of Good Hope. The 1769 transit presented more difficulty. The only European location possible was in northern Lapland. The British Government sent an expedition under Capt. James Cook to the island of Tahiti in the South Seas.

The transits of 1874 and 1882 were the subject of equally warm controversy. Stone, working with the results of the British observations of 1874, found 92,044,000 miles, while Col. Tupman, dealing with them differently, found 92,780,000. Airy, he who had been so sure of other previous values, made it 93,375,700 miles. Equally confident, he now said, "I do not think there will be anything to compete with the value thus deduced." The French found 92,044,-

[1] Parallax here refers to geocentric parallax, which is the angle subtended at the sun by the earth's equatorial radius.



The "black drop" effect is chiefly responsible for the uncertainty in timing the second contact of Venus when that planet transits the sun. When the planet is completely in front of the solar disk, irradiation and diffraction by the brilliant light of the photosphere cause the planet to appear smaller than it really is. At the instant of second contact, when the sun's limb and Venus' edge are tangent, these effects do not occur and a portion of the true limb of Venus is seen. However, this "black drop" lasts for several seconds, making observations of the contact uncertain. This, in turn, affects the solar parallax determination.

000, while David Todd, reducing photographic observations, found 92,011,000 miles.

The 1882 results were even less satisfactory. On the whole, the results of efforts to determine the sun's distance by observations of Venus were such as to lead astronomers to turn to the earth's neighbor planet on the other side, Mars, as likely to give more satisfactory information. Here, though, other troubles came into the picture; irradiation, diffraction, and optical defects in even the best telescope complicate the problem of finding Mars' parallax among the stars.

Galle (of Neptune fame) suggested looking beyond Mars to the asteroids, those tiny starlike (the name means just that) planets found in great number between Mars and Jupiter. The best values obtained from work on Mars gave a value for the solar parallax of 91,400,000, with a probable error of 500,000 miles; this was obtained by Stone in 1862. Winnecke found 91,200,000 from work done at Poulkovo and Capetown. Newcomb used 92,300,000.

In 1877, when Mars presented that most favorable opposition, famous for the discovery of its two tiny satellites and the "canals," the problem was most carefully attacked. Gill, afterwards government astronomer at Capetown, went to Ascension Island for the purpose of applying a method Flamsteed had advocated 200 years earlier. His result was 93,090,000 miles.

But the problem is still being worked over. Last year, in Vol. 101, No. 8, of the *Memoirs* of the Royal Astronomical Society, H. Spencer Jones, the Astronomer Royal, reports on a new determination. This was obtained from the 1931 opposition of Asteroid *433*, Eros, when it came within 16.2 million miles of the earth, its closest approach since its discovery in 1898. This was a particularly favorable occasion to find the distance to the sun. In 1928, a Solar Parallax Commission was appointed by the International Astronomical Union and preparation began in more than a dozen observatories scattered over the world. A most carefully laid out program and extensive observations and reductions resulted in a geocentric parallax for the sun of $8''.7900 \pm 0''.0008$. This corresponds to a distance of 93,003,000 miles, probable error, 8,000 miles more or less. This value is about 100,000 miles greater than we have been using in recent years.

Now we know how far away the sun is, until at some time in the future a new measure will put this one in the limbo of unused but not forgotten things.

The recorded diameter of the sun, of course, varies with the changing distance values. The angular diameter and the distance are used to work out the actual diameter in miles. The last is now close to 864,000 miles. That is hard to conceive—a diameter about 108 times the earth's, and a surface area 12,000 times as great—a volume equal to one and a quarter million earths rolled into one great globe.

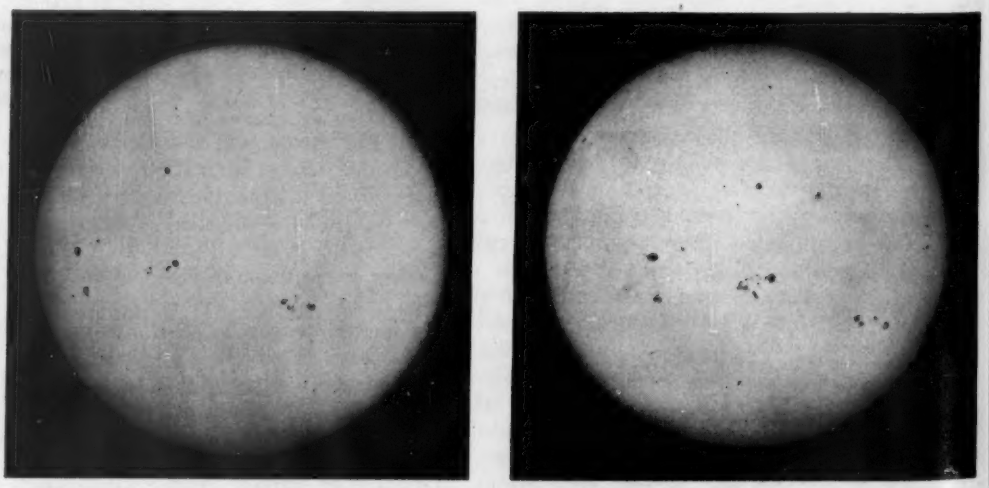
The question is frequently asked, "Does the sun move?" We have all been taught that it does not move around the earth, but that the earth moves around it. Strictly speaking, though, the earth does not revolve around the sun. The sun, earth, and all the planets, satellites, asteroids, and other members of the solar system, revolve around the common center of gravity of the system. But the sun is so massive that this point is near its surface, and the sun therefore "wobbles" around this point while it is spinning on its axis.

The sun's rotation was discovered almost as soon as Galileo discovered sunspots. Christopher Scheiner, a contemporary of his, made a fair estimate of the sun's rotation by studying the motion of sunspots.

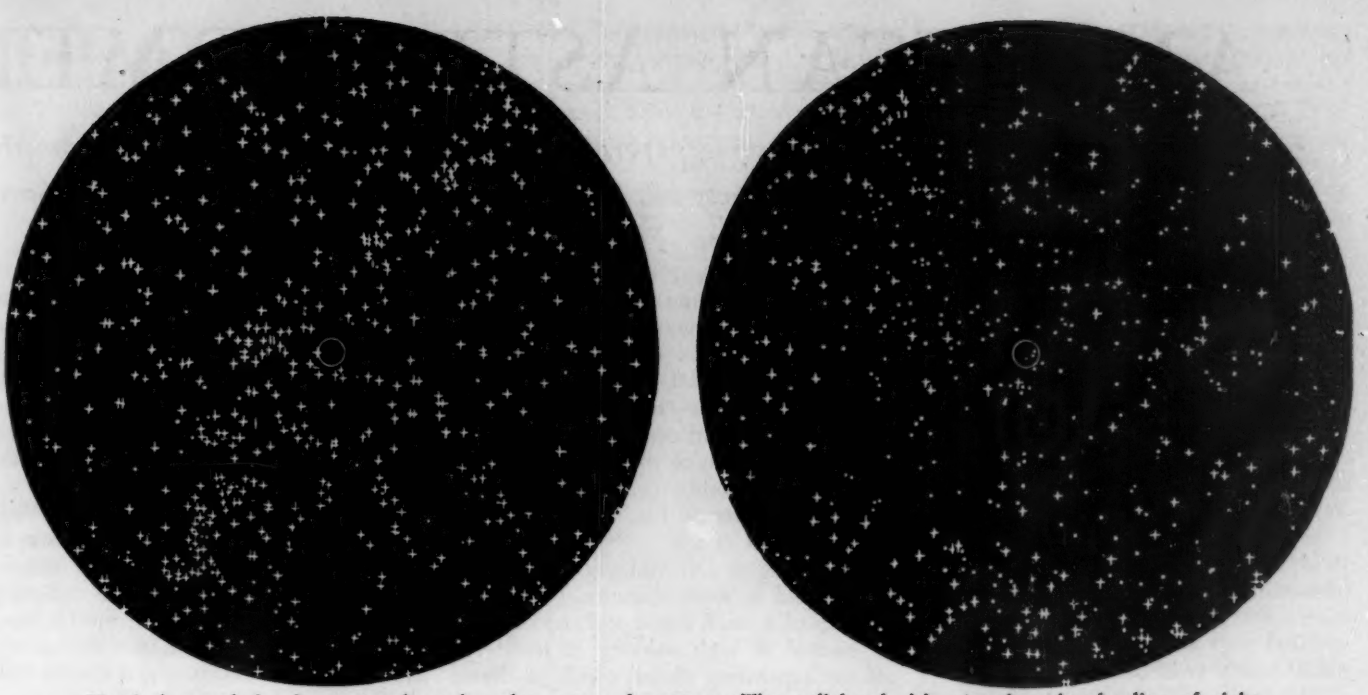
About 1850, Carrington and Spoerer made an accurate determination of the period of rotation, and noted, in addition, that the spots near the sun's equator complete their rotation in a shorter period than those in higher latitudes. These astronomers discovered that the sun's rotation is in the same direction as the earth's and around an axis that is pointing about midway between Vega and Polaris (18h 44m, + 64°). The equatorial belt spins in about 25 days, while at 30° in north or south latitude, the rotation is a day and a half longer. Fifteen degrees higher, it is slowed to 27½ days.

Such a rotation period may seem rather slow until we consider the sun's size. Its diameter of approximately 864,000 miles corresponds to a circumference of 2,714,000 miles. Spinning in 25 days means a speed on the equator of 108,500 miles per day, or 4,500 miles an hour—four and a half times the speed on the earth's equator.

Since sunspots do not appear above or below 45° north and south latitude, they cannot be used to measure the rotation over the entire solar globe. Recourse is had to the Doppler effect on spectrograms of the sun's limb. Since the west-



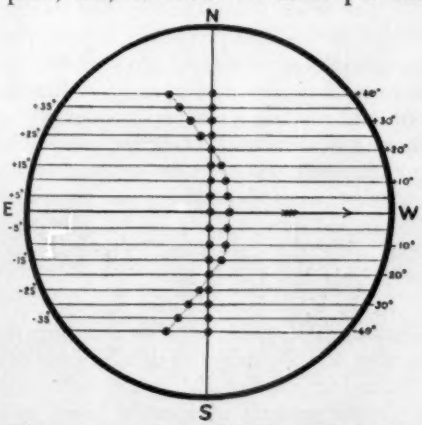
These photographs of the sun, taken with a small telescope, are two days apart. Observe the changes in the spots, as well as their rotation across the solar disk.



Hemispheres of the sky centered on the solar apex and antapex. The radial velocities (motions in the line of sight determined spectroscopically) of about 1,000 stars are represented. Stars which seem to move toward us are shown by dots; those moving away, by crosses. The predominance of dots in the right-hand hemisphere shows that the sun is moving toward its center, the apex.

ern edge is receding, the spectral lines there will shift toward the red. The eastern limb, approaching the observer, will show a violet displacement. This was first studied visually by Duner, of Sweden, in 1893. More extensive studies by Adams at Mt. Wilson showed that at latitudes of 80° the period was as slow as 33 days. However, spectral lines from different elements give different values. This might well indicate a stratification effect—different levels above the surface rotating at different speeds.

The sun is speeding along through space, too, at about 12 miles per second, carrying the entire solar system with it. This motion was first detected by Sir William Herschel in 1783. The story really begins 13 years earlier when Mayer, the first to attempt an interpretation of the proper motions of stars, concluded that no trend was noticeable. If the stars had no motion of their own, any motion of the sun (and the earth with it, of course) toward a particular spot would cause the stars in that region to show a tendency to separate. As a matter of fact, the stars are not at rest. They appear to move slightly, very slightly, in an apparently unsystematic way, but by taking averages we can rule out this haphazard motion. Mayer's researches on the subject, and his incorrect conclusions, were reported to the Academy of Sciences of Goettingen in 1760. His study covered 80 stars. Their proper motions were determined by a comparison between Roemer's observations in 1706 and Mayer's and Lacaille's in 1750 and 1756.



The rotation times of different latitudes of the sun are illustrated by this diagram. Seventeen spots are imagined five degrees apart on the sun's central meridian at the start of a solar rotation; at its completion, they lie on the curved line, those near the equator having well outstripped those in higher latitudes.

In 1783, Herschel examined the same subject and arrived at the opposite conclusion. His investigation was based in the first instance on work by Maskelyne. He obtained the result that the sun was moving toward a point in the constellation Hercules, which he called the apex of the sun's way. He then confirmed his studies with stars from Mayer's own list.

In that same year, Prevost, using Mayer's work again, deduced much the same result. Klugel, in the 1789 Berlin *Ephemeris*, again working with Mayer's studies, confirmed the position. The first studies on the speed came from Otto Struve. More recently, spectroscopic observations of stellar radial velocities have provided very accurate results. The apex is now considered to be at 18h, + 30°.

The sun likewise shares in the rotation of the galaxy (see the "Beginner's Page," this issue). If the galaxy itself is moving, our sun shares this motion, too. Probably it is, but this is a controversial subject, one that we had better leave for the present.

The sun, then, is quite a body as far as we are concerned, but not as stars go. With its little family of planets it is spinning and whirling along, separated by a distance of 25 trillion miles from its next nearest stellar neighbor. So we need not worry lest its cavortings may bring disaster by bumping into another star.

It might bump at that—perhaps it has. That may be the way the solar system got its start. If it repeats the performance, we might meet our end in the same dramatic fashion. There are other things the sun could do to bring to a conclusion the activity on this little planet. It might flare up as we have seen others stars do, but many students do not consider it the right type of star to become a nova. Or it may wear itself out by its own expenditure of energy.

In any event, the sun is shining in the sky today, pouring out its millions of tons of sun stuff every second to keep us warm, to grow our crops, to run our engines. We are learning about rationing fuel these days. The sun has always rationed its fuel. The ration for the earth is 1.8 horsepower for each square meter. We have not learned how to use it, directly. We do a little water heating and a few tricks in cooking with solar energy, but we largely depend upon natural processes to store it for us. Whether nature can replace her stores as fast as we waste them is a question.

We may some day find out how to use the sun's energy directly; then we can waste with impunity, and no one will be reminding us of the consequences.

AMERICAN ASTRONOMERS

The Editors review some papers presented at the 68th meeting of the American As
Complete abstracts will appear, as usual, in the Publications of the Society an
For a general story of the meeting, see page 3.

Comet Versus Planet

COMET Whipple 1933f was the subject of a paper by Richard N. Thomas, of Harvard. In 1922 the orbit of this interesting comet was nearly circular, as comet orbits go, and almost as large as that of Jupiter. But when the comet and Jupiter traveled together for a time during their close approach in 1922, the orbit of the comet was affected tremendously, so that now it alternately comes within 270 million miles of the sun and goes as far away as 480 million miles, nearly twice as far.

This latter is Jupiter's average distance from the sun, so there will be future occasions when the comet and the mighty planet wage their battle again. The comet will always lose. It lost three years of its "life" in 1922, for instead of taking 10 years for a trip around the sun, it now takes only about seven years. Before 1920, its history is uncertain, but an astronomer, with time on his hands, can compute backwards and find out whether or not this comet may once have had a much larger orbit than Jupiter's.

Nova Spectrum Interpreted

NEW stars, or novae, just "blow the lid off" before they let off steam, according to the interpretation of changes in novae spectra presented by Dr. Dean B. McLaughlin, of the University of Michigan Observatory. Although often called "exploding" stars, new stars apparently do not explode at all, the main part of the star remaining relatively stable during the tremendous outburst of light and energy.

Actually, new stars are old ones which flare up hundreds of thousands of times brighter in a few days. It has long been known that the flare-up is accompanied by the eruption of a cloud or shell of gas which expands about the star with a speed of hundreds of miles per second. This cloud eventually becomes visible as an expanding nebula, and it accounts for the broad bright bands with dark lines on their violetward edges, which are observed in the spectrum soon after the star has reached maximum light.

But there are many other features of a nova's behavior and spectral changes whose explanation is not so evident. Dr. McLaughlin stated that the additional sets of lines, known as the "diffuse enhanced absorption" and the "Orion absorption," had never been clearly assigned to a definite place in the nova. Similarly, the location of origin of some emission bands has not been specified definitely. The past interpretations, he pointed out, have been confused by dynamically absurd conjectures involving a rapid expansion of the *entire star*, followed by a bodily contraction of the whole star after it has "thrown off" a cloud or shell of gas.

According to Dr. McLaughlin, energy is released a short distance below the surface of a small dense star, and matter is ejected at high velocity in the form of an expanding cloud which is dense enough to radiate like an expanding star during the early stages of the expansion. Actually, the main body of the star remains relatively undisturbed by the intense superficial eruptive activity. The ejection of matter occurs in a tremendous "main burst," followed by a fairly continuous eruption of gas over a period of several weeks, with gradually decreasing violence. (The amount of gas ejected in a given time decreases steadily, though the speed of eruption increases, according to the observed spectral features.)

When the main burst has expanded so far that the gas can no longer remain opaque, the effective radiating surface shrinks within the outward-rushing cloud of gases. Since the main burst is now transparent, the bright bands appear, and the light of the star declines because the radiating surface is smaller.

Dr. Dirk Brouwer, director of Yale Observatory, and host at the June meeting of the American Astronomical Society.

The main burst is not detached in the form of a hollow shell; gases are continually ejected following it up. The nova may be said to have "blown the lid off," but the "steam" continues to rush out for a long time afterward. It is the main burst or principal shell that eventually appears as an expanding nebula.

After maximum light, when the effective radiating surface is farther down in the outward-rushing cloud, the atmosphere of gases just outside the radiating surface produces strong absorption lines which make up the "diffuse enhanced" system, with a velocity about double that of the principal shell. It has a rather short life, and its atoms, much fewer in number than those of the principal shell, give rise to multiple absorption lines when they have gotten far out from the star. Eventually they disappear because the gas becomes too thin to produce observable effects. In the meantime, the gases right around the smaller opaque cloud of dense outward-rushing matter around the star produce the Orion absorption lines and the "4640" emission band. In some novae, variations in the eruptive activity of the star show up as large oscillations of light, accompanied by strong variations of strength of these spectra which originate close to the star. The principal shell, remote from the star, is very little affected.

There is no contraction of the star involved in this interpretation. The apparent shrinkage is simply due to the recession of the level of opacity within the outward-rushing gases as the density of those gases declines. Gentler ejection of matter continues even for years after the outburst, as evidenced by the somewhat broadened bright lines of the post-nova star, after the expanding principal shell or nebula has faded away.

In the latest issue of *The Astrophysical Journal* (95, 428), Dr. McLaughlin describes the 26 stages in a nova's history. These include five absorption and seven emission systems of spectral lines, upon which his interpretation is based, and which are briefly as follows:

Absorption systems

1. *Pre-maximum stage*, from earliest date of observation of the star's spectrum until at least a day or two after maximum light.
2. *Principal absorption* spectrum becomes dominant within the first few days after maximum, and shows large Doppler shift.

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ty and elsewhere.

3. *Diffuse enhanced* are very strong and diffuse lines of hydrogen and ionized metals, with a Doppler shift about double that of the principal spectrum.

4. *Orion absorption,* strong, diffuse lines of HeI, OII, and NII, appears later.

5. The strong lines NIII 4097, 4103 are part of the Orion spectrum, but last after that system has otherwise disappeared.

Emission systems

1. *Pre-maximum emission,* found in Nova Herculis, and possibly in some other novae.

2. *Principal emission* appears after maximum light, closely associated with principal absorption. Redward edges of its bands show Doppler shifts roughly equal and opposite to the lines of the principal absorption.

3. *Diffuse enhanced* is associated with the similar absorption, but only for certain lines.

4. *Orion* is associated with Orion absorption.

5. Diffuse *"4640" emission* and NIII 4097, 4103 are part of the Orion emission, but last after it has disappeared.

6. *"Nebular" emission* is simply a continuation of the principal emission under altered physical conditions. The gas causing it eventually appears as an expanding nebula.

7. *Post-nova stellar emission* is visible on the continuous spectrum of the nuclear star.

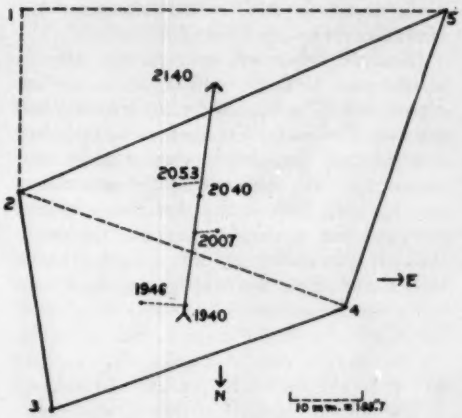
Parallax Problems—Future

DR. PETER VAN DE KAMP, of Swarthmore College, discussed the choice of configurations of reference stars in long-term astrometric problems, such as parallax and proper motion determinations. He said that in most photographic parallax measures with long-focus instruments, the material covers only a few years, and that even with a large proper motion of the central star, it has been found satisfactory to use one single configuration of reference stars.

The greatest measuring accuracy is reached by having the reference stars for parallax work form as small a configuration as possible. In a limited problem, such as a conventional parallax determination, nothing is more important than a small configuration, with each reference star contributing about equally in the measure.

However, he discussed the case where the path of the central star may reach the same order of size as that of the reference system. Since the latter is limited by the size of the telescopic field and the photographic plate, any configuration has only a limited lifetime within which maximum efficiency is reached. In any long-term problem in which measures of a star's positions are made, it is important to consider carefully the choice of reference stars, so that they will not get out of date early.

It is well known that not much accuracy is gained in using more than three



Reference configurations for Luyten's star, showing its change in apparent position (proper motion) from 1940 to 2140. Sproul Observatory diagram.

or four reference stars. Usually, a few possible configurations are likely to be found, all of them satisfying the condition that at some time in the future the path of the central star will pass close to their respective centers. To provide for the future, then, we may choose a small configuration, and consider the later addition of one or more stars, even though these might have little or no value at present.

Dr. van de Kamp used Luyten's star, with a proper motion of 3″.76 per year, as an example. The accompanying diagram shows five reference stars which seem eligible. For a short-term problem, the configuration 234 is adequate, while for long-term work 2345 and 12345 are preferable. In each case the positions of greatest accuracy are connected with the centers of the respective reference configurations, and the dates when the star will reach them are shown.

Measurements for Luyten's star were started in 1937. At that time the accuracy of the 2345 arrangement was hardly superior to 234. But the latter reaches a maximum accuracy in 1946, and then decreases, while the 2345 accuracy will increase until the year 2007. Star 5 is already contributing to the measures, and to a greater extent each year as Luyten's star approaches it.

The only alternative remains the 12345 configuration, which reaches maximum accuracy in 2053, and thus will last a century longer than the 2345 group. However, star 1 will contribute nothing until 1955, and very little until 1980. Therefore, even if it were decided to use the 12345 configuration, it would be a great waste to measure star 1 at the present time. Future observers may wish to add it, if they are still interested in this particular star, and we can work on the basis that they will probably do so.

The Revised Multiplet Table

FOR some years the Princeton University Observatory has been the clearinghouse for spectroscopic information. One of the chief purposes of this project has been to supply astronomers with data needed in the study of the spectra of various types of stars. Dr. Charlotte E. Moore reported the progress being made on a revision of the book, *Multiplets,* published in 1933 at Princeton, which gives spectroscopic data of interest to astronomers.

These data consist of analyzed laboratory spectra of various elements, for wave lengths longer than 3000 angstroms. Selected and related groups of lines called multiplets are given, together with their excitation potentials, which indicate how much energy is required to produce the various lines in the laboratory. To date the arc spectra of 23 elements and the spark spectra of 20 are completed ready for publication. Some of these elements are scandium, titanium, vanadium, chromium, manganese, cobalt, and nickel, and a number of the rare-earth elements.

The revision contains a wealth of unpublished material generously provided by various collaborating individuals and institutions.

60,000 Estimates

A 70-FOOT plot of the light curve of SS Cygni, irregular variable star well known to amateur observers, was described in a paper submitted by Leon Campbell, recorder of the American Association of Variable Star Observers. This star was discovered by Miss L. D. Wells at Harvard in 1896. Since then, nearly 60,000 estimates of its brightness have been received, representing the observations of over 500 observers, some of whom have watched the star for 20 years or more.

Normally a 12th-magnitude star, about every 50 days SS Cygni bursts forth and becomes 20 or 30 times brighter, reaching nearly the 8th magnitude. Over 330 such outbursts have been recorded, some lasting only a few days, while others stretch over several weeks. But in 1933-34, the star decided not to follow its usual pattern at all, adding to the mystery of its behavior.

Amateur Astronomers

First Great Lakes Regional Astronomical Convention

Reported by Louise Bahr

THE First Regional Convention of amateur astronomers was held in Chicago, June 13th and 14th, at the Congress Hotel. There were representatives present from Illinois, Indiana, Michigan, Ohio, and Pennsylvania. Dr. Frank Hancock, president of the Burnham Astronomical Society of Chicago, presided at all the sessions.

Outstanding event on the program was an excursion to Yerkes Observatory, Williams Bay, Wis., on Saturday afternoon and evening. The 40 persons who made the trip were privileged to observe the globular cluster, M13, in Hercules, and the Ring nebula in Lyra, through the largest refracting telescope in the world.

Outstanding accomplishment of the meeting was the formation of the Great Lakes Regional Astronomical Society, which has as its aim incorporating all the amateur societies in the states contiguous to the Great Lakes into a regional organization, the purpose of which will be to hold one or two regional conventions in different parts of the area each year.

At 10:30 a.m. on the 13th, Carl H. Gamble, of Moline, Ill., gave a talk entitled "My Hobby." While a boy in his teens working on a farm, he became interested in the heavens when he noticed that the stars were not in the same location in the springtime as they were in the fall of the year; sometimes he could see certain constellations and at other times they were not visible. Mr. Gamble's interest lay dormant for many years, but was revived in 1930, when he purchased a telescope. He built Sky Ridge Observatory, where he now holds public nights frequently. (See *Sky and Telescope*, January, 1942.)

Miss Winifred Sawtell, of Oak Park, Ill., followed with a lecture on "The Moon." As a sequel to this, in the afternoon Dr. Hancock spoke on "The Sun."

It rained while we were on our way in private cars to Lake Geneva, where we ate dinner at 6:00 p.m., but by the time we had reached Yerkes Observatory, the rain had stopped and the clouds were rapidly disappearing. We were splendidly entertained by Dr. Otto Struve, the director, who had arranged for a student to take the party through the buildings; the telescopes were shown and their mechanism explained, creating much interest. As the skies cleared, we observed with the great 40-inch refractor. On Sunday, a vote of thanks was extended to Dr. Struve for his hospitality and interest.

The session Sunday afternoon was begun with a talk by Robert L. Price, of Joliet, Ill., who spoke on "The Changing Conception of the Universe." Mr. Price gave an extensive list of the men who had made scientific contributions to the world and described their discoveries. He endeavored to show how man's mind has had to keep pace with the ever-enlarging universe.

"The Folly of Astrology" was the subject of a lecture by the Rev. Daniel J. McHugh, president of De Paul University. He condemned this pseudo-science as a violation of the First Commandment, and stated that astrology destroys faith in religion. In several humorous moments, he showed how the casting of horoscopes is unreasonable, unwarranted, and ineffective.

Measuring the velocity of light and the diameters of the stars were A. A. Michelson's greatest contributions to the world, according to Prof. Clarence R. Smith, of Aurora College, who lectured on "Michelson —the Man Who Measured the Stars." The speaker also told how Michelson, who died only 11 years ago, is credited with having duplicated the length of the standard meter.

At 5:30 p.m., Sunday, William Callum, who gave a history of *Sky and Telescope*, said it was an indispensable magazine for amateur astronomers, as well as a means for communication between them.

At the business meeting, the Great Lakes Regional Astronomical Society was organized, and Dr. Hancock was voted president for one year. Other officers elected were: 1st vice-president, Robert L. Price; 2nd vice-president, Carl H. Gamble; 3rd vice-president, Charles Graham (of Michigan); treasurer, William Callum (of Chicago); secretary, Clarence R. Smith.

The president of the G. L. R. A. S. was given power to appoint additional members to the executive committee and any other committee he may find necessary.

The boundaries of the Great Lakes region were not decided, but as a starter it seemed feasible to include Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin.

NEW YORK AMATEURS VISIT HARVARD

DESPITE wartime restrictions on transportation facilities, about 20 members of the Amateur Astronomers Association of New York City made their 1942 annual field trip to Harvard College Observatory at Cambridge, Mass., on Memorial Day weekend, headed by Secretary George V. Plachy. The group was entertained by Charles A. Federer, Jr., and staff associates of Harvard.

Saturday afternoon was spent attending a lecture on variable stars by Dr. Dorrit Hoffleit, and examining facilities at the observatory itself, which include the famous 100-year-old 15-inch refractor, modeled after that of Poulkovo Observatory in Russia, which was recently reported destroyed during a Nazi attack.

Tea was served in the observatory lounge through the courtesy of Leon Campbell, well known to amateur astronomers as the recorder of the A.A.V.S.O.

Although a gibbous moon and slight haze somewhat handicapped the "seeing," considerable observing was done during the evening, using the 9-inch Jewett telescope.

On Sunday, the party stopped at historic points in Lexington and Concord en route to the Oak Ridge station of Harvard Observatory. Drs. George Z. Dimitroff and Bart J. Bok greeted the visitors upon arrival there, and a most interesting time was passed inspecting the new Schmidt camera, the 16-inch Metcalf telescope, and particularly the big 61-inch reflector. Rides on the observing platform up into the dome, a look at the patrol cameras, and demonstrations of other important pieces completed an exciting tour. Colored motion pictures for the A.A.A.'s documentary film were taken by Peter A. Leavens, the association's chief photographer.

All those who participated are grateful for the courtesy and patience of the Harvard staff.

GEORGE V. PLACHY, secretary

PITTSBURGH AMATEURS ACTIVE

DR. W. N. ST. PETER, professor of physics at the University of Pittsburgh, was the guest speaker at the May meeting of the Amateur Astronomers Association of Pittsburgh. His subject, "Physical Principles That Have Been of Aid in Astronomy," was presented in his usual interesting and enlightening manner. The attendance was above average and the audience enthusiastic. Our June meeting takes place at the summer home of one of our members, Roelof Weertman, of Beaver, Pa. It will be an outdoors affair, with observing through Mr. Weertman's 12-inch telescope.

New officers of the A. A. A. of Pittsburgh have been elected for the next year: C. A. Atwell, president; H. N. Priest, vice-president; Louis E. Bier, secretary; C. W. Fischer, treasurer. In spite of the stress of times, we are all anticipating a very active year ahead.

Beginning Monday, June 1st, and continuing every evening thereafter until November, the A. A. A. of Pittsburgh, in co-operation with the Pittsburgh Bureau of Parks and Allegheny Observatory, is conducting the Summer Star and Constellation Study Group. In its seventh consecutive year, the group is open to the public. In bad weather a lecture is planned, but when the sky is clear, the meeting is divided into two sections.

The constellation classes will continue to meet as one section. Under the leadership of Fred Garland, former A. A. A. president, the main theme of the second group is astro-navigation, therefore of interest to young men in navigation or aviation. Further information on these classes may be had by calling the Wissahickon Nature Museum, Fairfax 1716.

LOUIS E. BIER, secretary

DETROIT AMATEURS OBSERVE MERCURY

THE Detroit Astronomical Society held a portable telescope meet on the sun roof of Hotel Webster Hall, the evening of May 23rd, and those who attended were fortunate in having first-class visibility. The glowing crescent form of Mercury was picked up, and in the amateurs' telescopes it seemed to outrival the sharply-cut shadows of the craters on the moon, which was at first quarter.

The meeting was held primarily for students in the astronomy classes of Prof. E. R. Phelps at Wayne University, and was enjoyed by members and students alike.

MARGARET BACK, secretary

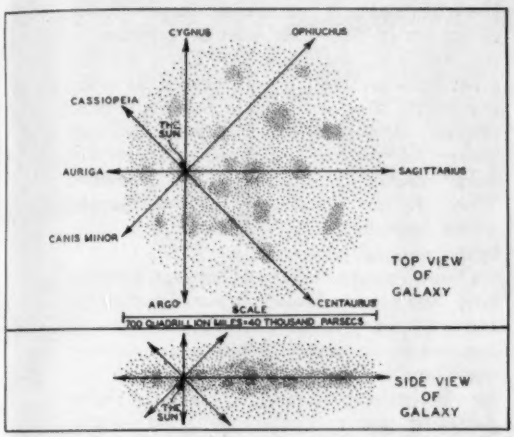
BEGINNER'S PAGE

By Percy W. Witherell

The Milky Way

ONLY those who have been privileged to observe the Milky Way on a midsummer, moonless night from a free-from-light and clear-of-haze location in the country have any conception of its beauty. Perhaps the dimouts and blackouts in our cities will help our urban populations to appreciate the existence of this great band encircling the sky.

In July, during the early evening in northern latitudes, may be seen one of the most beautiful portions of the Milky Way, extending from Cassiopeiâ (the *W*) in the northeastern sky, through Cepheus and Cygnus (the Northern Cross) in the zenith. Here it divides into two parts and continues through Aquila and Scutum to Sagittarius in the west.



The observed distribution of stars in the sky is explained by this diagram of the Milky Way seen along two different planes.

Later in the night or the season, the regions in Perseus, Auriga, and Taurus may be seen. In the southern hemisphere of the sky are star-packed areas in Centaurus and Crux (the Southern Cross), extending through Carina, the brightest portion of the southern heavens. There, close to the Cross, is the peculiar Coalsack, which is darker and with fewer visible stars than the great dark rift in Cygnus and Aquila. However, to see all these southern sights to best advantage (at least 20 degrees above the horizon), the observer must be as far south as the earth's equator.

As the use of any optical aid brings into view the fainter and more distant stars, the ratio of those seen in the Milky Way to those in a direction perpendicular to it increases from three to one with binoculars, to more than 10 to one with a 15-inch telescope.

The co-operative studies of the Milky Way carried on at many observatories have increased manyfold our knowledge of the structure and dynamics of the galaxy since the first really comprehensive observations made by Sir William Herschel. The Milky Way galaxy is now believed to be an ill-defined circular disk about 100,000 light-years[1] in diameter, with a globular nucleus in its center. This is in the direction of Sagittarius, where the greatest width and brightness of the Milky Way is seen. The sun is located about 30,000 light-years from this center, and about 50 light-years above (north) of the central plane of the system.

The entire galaxy is rotating about the center, its outer portions revolving in longer periods after the manner of the more distant planets around the sun. At the sun's distance from the center, the *cosmic year* is equal to about 200 million of our ordinary solar years. The sun's speed around the galactic center is about 150 miles per second.

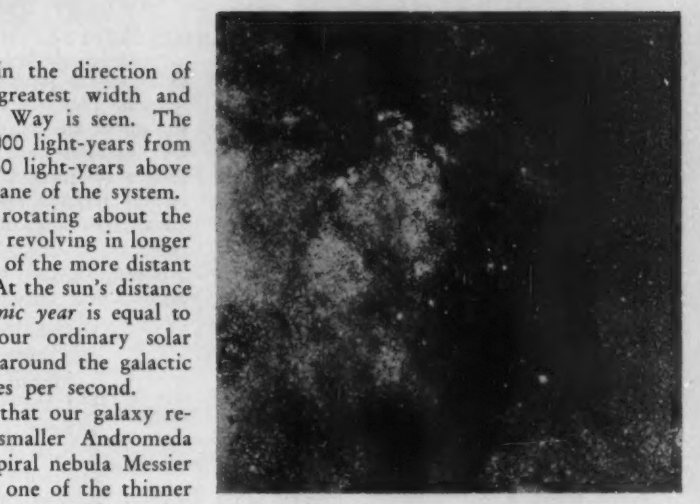
It has been suggested that our galaxy resembles the somewhat smaller Andromeda nebula or possibly the spiral nebula Messier 33. The sun may be in one of the thinner spiral arms, and there is some evidence that it may be in one of the dark pockets.

There are several billions of stars in our galaxy, with more than 400 faint galactic clusters lying along its edge within a few degrees of the galactic plane, and 100 very distant globular clusters, over one third of which are in Sagittarius in an area that occupies only two per cent of the entire sky.

The Pleiades, the Hyades, Praesepe (the Beehive), and the Double Cluster in Perseus are examples of easily seen galactic clusters. In most of these, the members are observed to be moving as a group in the same direction. The Hercules cluster (M13) is a globular cluster, as are also 47 Tucanae and Omega Centauri, of the southern sky. The typical galactic cluster has from 20 to 1,000 stars; the globular clusters average 100,000 members.

There are numerous faint, gaseous nebulae along the galactic plane. The bright gaseous nebulae are illuminated and excited to shine by adjacent hot stars; they are very beautiful objects—the Orion nebula, the Trifid, and the Eta Carinae nebula are well-known examples. There are also many "dark" nebulae, such as the Horsehead, the Coalsack, the "Gulf of Mexico" in the North America nebula, which are masses of dust and gas that are not illuminated. These dark masses obscure many distant stars which undoubtedly are located behind them.

Hydrogen, sodium, calcium, and other elements, and cosmic dust are shown by the spectroscope to exist throughout the galaxy, and they complicate the study of the system at the same time that they contribute a powerful means of measuring large distances. Interstellar gases and dust in the galactic plane cut off our view of many extragalactic nebulae, which we may consider distant cousins, and of whom we hope to learn more in coming years. These other galaxies bear great resemblance to our own.



The Milky Way in Aquila and Scutum, showing myriads of stars and lanes of obscuring nebulosity. M11 is 5/8″ from the left side and 7/8″ from the top of this picture, which should be compared with the larger scale back-cover photo of the Scutum cloud.

Our galaxy's nearest full-fledged neighbor is the Great Spiral in Andromeda. The naked eye sees it as an elongated patch of light near the Great Square of Pegasus, but even this reproduction does not show its true extent: the circles indicate regions on the original negative with surface brightness equal to that in our galaxy at the position of the sun.

[1] A light-year is the distance light travels in one year. Light's speed in space (practically a vacuum) is 186,271 miles per second. There are roughly 86,400 x 365¼ seconds in a year; therefore, a light-year equals somewhat less than six trillion (6 x 10^{12}) miles, or in numbers, 6,000,000,000,000 miles.

GLEANINGS FOR A. T. M.s

EDITED BY EARLE B. BROWN

REFRACTOR VERSUS REFLECTOR

TO the uninitiated, the word *telescope* would probably never be associated with any instrument which did not look like the familiar spyglass; in other words, to the laity, *telescope* is synonymous with *refracting telescope.* Conversely, the neophytic A.T.M. is seldom placed in contact with anything but a reflecting telescope, and the term, *telescope maker,* becomes synonymous with *mirror maker.*

As one becomes better acquainted with astronomy, by reading and by visiting some of the great observatories, he discovers that many of the best instruments are refractors, and perhaps he wonders why both types are present and why the better of the two does not predominate. Probably he wonders if he could make a refractor for himself, and whether or not it would be better than his reflector.

Of course, a refractor is a telescope which has a lens for its *objective,* while a reflector has a mirror, often called the *primary,* as there are usually one or more secondary mirrors. The lens in the refractor bends the light rays to form an image, whereas in the reflector they are reflected from the curved surface of the mirror for the same purpose. Our intention here is not to explain how the images are formed, since this has no bearing on the relative merits, but to consider the advantages and disadvantages of the two types.

Some of the requirements of a good astronomical telescope are:

1. Definition
2. Achromatism
3. Magnifying power
4. Light-gathering power
5. Resolving power
6. Size of image (usable field)
7. Flatness of field
8. Versatility
9. Cost
10. Ease of construction
11. Convenience of handling
12. Upkeep

This list is not complete, nor does it apply in every case, since for some particular purpose, many of these features may not be important. However, let us compare the average reflector and refractor according to these requirements.

1. **Definition.** The refractor is definitely superior in definition. A lens can be corrected to almost any desired degree (theoretically) for all of the six primary[1] and many of the higher aberrations. The usual astronomical refractor contains a lens of two components, comprising four surfaces, which the designer can balance against each other to overcome aberrations; for finer corrections, more components may be added. In the reflector, however, the designer is restricted to certain specifically required geometrical surfaces, and he must accept the aberrations as they come. Each of the reflector types, Newtonian, Cassegrainian, Gregorian, Ritchey-Chrétien, and so forth (see "Gleanings," June, 1941), has its own degree of correction for the various aberrations, beyond which no further corrections can be made. In certain cases, correcting lenses are placed in the optical system to correct for some aberrations, particularly coma, with which the reflector is especially afflicted.

Generally, refractors are more thoroughly corrected for aberrations than reflectors, with two exceptions: First, the reflector is completely free of chromatic aberration, because the law of reflection is independent of the wave length of the light (but the law of refraction is not). Second, the parabolic mirror is completely free of all aberrations *on the optical axis.* But this second condition can be theoretically true for only a single geometric point, that is, for one star.

Obviously, any aberration reduces the quality of the image. Further, the reflector is subject to a loss in definition because of the blocking out of light by the secondary and because of diffraction from the legs of the secondary support.

Hence, if excellent definition is the essential quality of a telescope, the choice of a refractor is indicated.

2. **Achromatism** is freedom from chromatic aberration, and here, as stated above, the reflector is superior, being completely achromatic by reason of its operating principle. For spectroscopy, and any work involving the quantitative or qualitative analysis of light, the reflector is definitely superior.

3-4-5. **Magnifying power** depends upon the focal length; **light-gathering power,** upon the area of the objective; and **resolving power,** upon the diameter of the objective. Theoretically, there is no choice between the two types for any of these factors. But in practice certain restrictions are present. Lenses can be made only so big (40 inches is considered the largest practicable), because too large disks cannot be supported around the edges and still retain their shape. Hence, telescopes of large size must be reflectors—the 100-inch, the 200-inch. Thus, for the great light-gathering power needed to study the Milky Way star clouds and the distant nebulae, as well as for the great resolving power for resolving globular clusters and spiral nebulae, large reflectors are necessary. They are also invaluable in spectroscopy, where high-dispersion spectra require great light-gathering power.

Unfortunately, because they are particularly subject to atmospheric disturbances and poor seeing, large-diameter telescopes do not result, in actual practice, in a really significant increase in resolving power. Size for size, the refractor has greater light-gathering power than the reflector because the secondary mirror in the latter obstructs from 10 to 25 per cent of the incident light.

Magnifying power is the ratio of the

[1] Chromatic and spherical aberration, coma, distortion, astigmatism, and flatness of field.

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focal lengths of objective and eyepiece. But the highest practicable magnifying power for a given telescope is dependent, of course, upon the resolving power of the telescope and the quality of the image (definition). The quality of the refractor image is slightly better, hence it is usually possible to use a slightly greater magnifying power than in a reflector of similar optical dimensions.

6. **Size of image.** Except for certain special types of work, it is usually desirable to have a large field of good definition. This is especially true in mapping the sky and star counting. Here the refractor is immeasurably superior. The usable field of a reflector is limited both by the oblique aberrations and by the necessarily small size of the secondary mirror. The diameter of a reflector image is never as great as one half the diameter of the primary mirror, while it is not unusual to cover a 20 x 24-inch photographic plate with a 5-inch or 6-inch lens, and to obtain reasonably good definition all over the plate.

7. **Flatness of field.** Since nearly all modern astronomical work is photographic, flatness of field (that is, of image surface) is advantageous. Only the refractor can have a flat field over any reasonably large area.

8. **Versatility.** Here the reflector comes into its own. Nearly all large reflectors are so made that they may be converted, in a few moments' time, from Newtonian to Cassegrainian, and even to several different applications of the Cassegrainian. If provided for in the original design, any reflector may be made convertible into as many different focal lengths as desired by merely substituting one secondary mirror for another. This cannot be done with a refractor.

9. **Cost.** This is not usually a problem for an observatory instrument, but it may be so in the amateur's case. Although the tube and mounting for a small refractor would probably be less costly than for a reflector, the refractor, diameter for diameter, is a much larger (that is, longer) instrument, as refractors are usually made with a focal ratio of about f/15, whereas reflectors are f/8 or shorter. And the cost of the optical glass alone would make the refractor far more expensive.

10. **Ease of construction.** A professional telescope maker would probably consider the refractor easier to construct, but the reverse is true for the A.T.M. In the first place, most telescope makers want to build their telescopes according to their own individual designs. Unless an A.T.M. is thoroughly familiar with theoretical optics, the computation of a good objective lens is a problem he cannot possibly handle. And further, even if he adopts a standard design, he has four surfaces to grind, polish, and figure, instead of the single surface of the reflector. Refractor construction is a project for an experienced and conscientious hand; nevertheless, let no one believe that an amateur cannot make a good objective lens. Many amateurs have, and many more should try.

11. **Convenience of handling.** Because of its shorter focal length, and because, in such forms as the Cassegrainian, the tube may be made much shorter than the focal length, the reflector is much more conveniently handled than the refractor of the same aperture. A 12-inch reflector may be carried in an automobile, but a 12-inch refractor is a tremendous instrument, requiring a 20-foot dome to house it. (See "Gleanings," February, 1941.)

12. **Upkeep.** A mirror, being unprotected, requires much more care than a lens. It must be resurfaced from time to time, and frequently cleaned, when constant care must be taken to see that it is not scratched or damaged.

Certain types of telescopes, which are neither refractors nor reflectors, but a combination of the two, have been developed, notably the Schmidt camera ("Gleanings," July, 1940), and the other systems evolved from Schwarzschild's equations. The Schupmann telescope ("Gleanings," September, 1941), whose merits are yet to be proven, is another type of reflector-refractor combination. Although these combined types, like the reflector, cannot be adjusted for aberrations, they possess certain advantages over the reflector. For instance, the Schmidt has a wide angular field of good definition, but the limitation on size of plate permitted in the reflector still holds for the Schmidt.

Evidently, there is no answer to the question, "Which is better, refractor or reflector?" unless it be, "Well, that depends on whether . . ."

ASTRONOMICAL ANECDOTES

DIAMETERS; URANUS VERSUS NEPTUNE; HI-HO

RECENTLY I was asked to prepare a diagram illustrating the relative sizes of the planets and the sun. I recalled that once I had had some doubts about the accuracy of the figures given for these diameters in a popular textbook, and this time I was resolved to use the best available figures. I decided on the values given in the *American Ephemeris and Nautical Almanac*, for if these values cannot be trusted, there are none that can. It is somewhat disturbing, however, to find the diameters listed there to the hundredth of a mile! Surely we are not entitled to seven significant figures in the size of Neptune, when its angular diameter can scarcely be measured to three significant figures. For the sun, the diameter can be obtained from the *Nautical Almanac* to eight figures, again the hundredth of a mile!

There seems to be a good deal of disagreement as to whether Uranus or Neptune has the larger diameter. The *Nautical Almanac*, the *Handbook* of the Royal Astronomical Society of Canada, Duncan, Moulton, Fath, and others, cast their vote for Neptune; Russell, Dugan, and Stewart, Baker, Skilling and Richardson, and Whipple (and again others) prefer Uranus. Surely there is more than a matter of opinion here; one of them is larger, and which one is it?

The sources named above give the following extreme values:

Object	*Range*	
Sun	from 864,000	to 864,392
Moon	2,160	2,163
Mercury	3,000	3,100
Venus	7,575	7,700
Mars	4,215	4,220
Jupiter (equatorial)	88,640	88,698
Jupiter (polar)	82,788	82,800
Saturn (equatorial)	74,100	75,060
Saturn (polar)	66,300	67,170
Uranus	30,878	32,400
Neptune	31,000	33,000

If for no other reason than to save amateurs and beginners endless confusion, someone, perhaps at the Nautical Almanac Office, ought to prepare a paper on the subject, giving the best acceptable values for each of these diameters, and some measure of the uncertainty for each one; then it might well be some kind of heinous offense for any textbook writer to use figures other than these!

The stock examples of astronomical offenders are Hi (or Hsi) and Ho, who are said to have been beheaded because they failed to predict an eclipse of the sun. Chinese scholars even identified the eclipse as that of 2155 B.C., but it has been shown that that eclipse was not visible in China, so we have the jingle:

Here lie the bones of Ho and Hi
Whose fate, though sad, is risible;
They were hanged because they did not spy
The 'clipse which was invisible.

I hasten to add that I know the other stanzas, too; and I shall sometime compose still others to finish the story once for all.

Beheaded they are, by rumor; hanged they are in the verse above; doubtful is it that anything happened to them, for: "No astronomer in primitive China can have been expected to predict eclipses. Eclipses were not regarded as happening by natural law. They were supposed to be disturbances of natural law, produced through the kinship of Earth and Heaven by the errors of the people, and more particularly of the emperor. That Hi and Ho erred in failing to predict an eclipse is therefore intrinsically impossible, and it is also inconsistent with the language of the text on which the assertion was based." This was written by the best of authorities on ancient eclipses and historical astronomy, the late Dr. J. K. Fotheringham, in an article in the *Journal* of the British Astronomical Association, April, 1933.

In the preface to the *Shu King*, which escaped burning in 212 B.C., there is this: "Hi and Ho, sunk in wine and excess, neglected the ordering of the seasons, and allowed the days to get into confusion. The Prince of Yin went to punish them." Fotheringham studied all the original sources, and came to the conclusion that Hi and Ho were colleges or societies of astronomers, and not individuals, and that their duties included the preparation of almanacs. The emperor was opposed by a usurper who had a powerful army; the emperor ordered the punishment of Hi and Ho for some real or suspected offense in order to drum up a bigger army. Then he tackled the usurper, but death ended the struggle for the emperor, and the usurper came into sole power.

The only statement that Hi and Ho were even liable to punishment by death comes from a garbled late account which is a hodgepodge of miscellaneous information from various sources. Its only redeeming feature is the concluding sentence:

"The statutes of government say, when they anticipate the time, let them be put to death without mercy, when (their reckoning) is behind the time let them be put to death without mercy." I'd like a third choice, for myself!

R.K.M.

BOOKS AND THE SKY

ENJOYMENT OF SCIENCE

JONATHAN NORTON LEONARD. Doubleday, Doran and Co., Inc., 1942. 327 pages. $2.50.

IF the many popular books on science to which Mr. Leonard refers in his *Enjoyment of Science* were as entertainingly written as the author's own volume, he could feel confident that he had succeeded in his purpose of creating a hobby in science for most of his readers. The book might fittingly be entitled, *How to Read Science Intelligently*, and could well form the background for an introductory course in adult education on the fascinating but generally avoided fields of the physical and natural sciences.

The author divides the sciences into three categories which he bases upon "the spirit of their written literature": (1) the laws of the universe, which includes logic, mathematics, physics, and chemistry; (2) the "thing sciences," which includes astronomy, geology, oceanography, meteorology, mineralogy, paleontology, and geography; (3) the life sciences, in which category are the many ramifications of the biological group. Group 2 is distinguished from group 1 in that science here deals with particular things rather than abstract ideas, although there are far from fixed boundaries between the groups.

The author encourages the early explorer into the fields of science first to become familiar with the objective sciences that deal with things. He rather startles the adult reader with the encouraging thought that the mature mind learns more easily than that of the adolescent, so that books on science which might have been found difficult in youth are more readily mastered at maturity. Perhaps there is some basis for this if one were to disregard the mastery of technique in a highly specialized field. After the introductory chapters, the author surveys in turn the biological, physical, and natural sciences, covering the whole ground, necessarily superficially, from insects to galaxies.

It is always interesting to note the relative values which an author places on different aspects of a subject by the relative space devoted to certain topics or the omission of a topic altogether. Little or nothing is said of the cyclotron and atom smashing, which at present hold the public eye in physics; this probably because the author regards nuclear physics as too intricate a subject to introduce to the lay reader. In astronomy, three pages are devoted to meteors or "shooting stars," while the sun, whose radiation is the source of all life on the earth, and whose vagaries are intricately interwoven with all radio communication, is dismissed with an 8-line paragraph, since the author regards "its chief value...as a laboratory and a standard of comparison for use in exploring the outer regions of the universe."

Even the professional scientist can learn much of how others see him from the pen of Mr. Leonard, who rather intelligently looks upon scientists from a gallery seat.

The chapters on the several sciences are followed with excellent bibliographies of what to peruse of the more readable literature available to the layman. These bibliographies are far from a mere catalogue of current sellers in science. The author's remarks scattered here and there relative to the books concerned are somewhat reminiscent of student syllabi prepared for unknowing freshmen and sophomores confronted with the college elective system. One learns, for example, which books are "marred by non-descript flippant humor aimed at juvenile minded college students," and those which are "pretty tough reading but fine if you want to know about the structure and history of a particular region." Then there are those volumes which are "tremendous, enormous, badly organized.... Interesting if read with intelligent skipping." Among these book notes, one learns that one physicist "is looked at slightly askance by some astronomers," and that Harvard Observatory has become "the headquarters of American astronomy"; while David Woodbury's *The Glass Giant of Palomar*, describing the 200-inch telescope, Caltech's pride infant, is not out of date, "because the telescope will not be finished for a good long time yet."

Altogether the book is interesting, amusing, and instructive. If the reader goes immediately to the public library to peruse some of the more popular books on science, he will obviously be going a long way toward helping the author realize the purpose for which the book was written; and no one who does so can avoid profiting thereby.

HARLAN T. STETSON
Massachusetts Institute
of Technology

STAR MAPS FOR BEGINNERS

I. M. LEVITT and R. K. MARSHALL. The authors, The Franklin Institute, Philadelphia, Pa., 1942. 33 pages. 50 cents.

TWO members of the staff of the Fels Planetarium have collaborated in producing a delightful introductory text combined with an extremely practical set of star maps for beginners, as well as advanced students, in observational astronomy. There seems to be no other inexpensive publication which serves so well the needs of watchers of the skies who desire, in condensed form, modern constellation maps together with supporting descriptive material on many objects of special interest.

There are 12 star charts, seven by seven inches, one for each month, showing the constellations in white on black. Those who consult star maps out-of-doors at night know how desirable it is to have charts with a black background. The customary white maps leave the vision handicapped for a minute or so after being consulted under flashlight. A new "clover-leaf" type of map projection has been employed by the authors which, in faithfulness of proportion among sky areas, leaves little to be desired—short of the globe-type map. (However, astronomical globes, while most accurate in areas, are somewhat impractical outdoors, and continue most annoyingly to be printed "inside-out" so that all the constellations appear reversed!)

A minor criticism of the maps lies in the width of the lines used to connect the individual stars into their familiar constellation patterns. While the authors seem to have sensed this objection in advance (the lines are indeed much finer than on most maps), considerable improvement might yet

From Copernicus to Einstein
By HANS REICHENBACH

THIS is a simple but scientific history of the ideas and discoveries that have led to the formulation of the theory of relativity. The story begins with the revolt of Copernicus against the Ptolemaic system and presents a systematic development of his views of the world. It shows how the modern conception of space and time has been affected by findings in the field of light and electricity. The theory of relativity is demonstrated to be an outgrowth of these two major trends and is discussed briefly but so clearly as to be readily understood by any intelligent layman.

Professor Reichenbach's work is, however, by no means a popularization. The wealth of ideas contained in it tends to make it a distinguished contribution to contemporary thought.

It is well illustrated with charts and diagrams. The book is especially intended for the scientific as well as amateur astronomer and physicist.

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be made. Often the uninstructed eye of the beginner will itself fashion the stars into more convenient patterns than the traditional figures. It may well be, however, that this problem could not be entirely solved only because of the lithographing process used in the printing of the maps.

The accompanying text is introduced by a fascinating history of the development of the constellations, which, in the authors' words, "has never appeared in so complete yet so concise a form." A modern list of the 88 constellations is given, with several welcome improvements in translation of Latin names, as well as a 6-year table (1942-1947) of positions of the brightest planets—Venus, Mars, Jupiter, and Saturn.

The body of the text, placed directly opposite the pertinent map, combines in happy proportion standard material on the description of the classical constellation figures and their mythology with basic elementary astronomy. Sprinkled throughout are explanatory paragraphs on such choice astronomical morsels as spiral nebulae, the zodiac, the light-year, eclipsing variables, the Milky Way, spectra-color-temperature relation, globular clusters, Cepheids, novae, galactic rotation, and so on—all woven into the story of the stars as considered by constellations.

This reviewer recommends *Star Maps for Beginners* as a unique and practical addition to any astronomical library. The beginner will readily understand it; the active amateur will find it handy and useful for reference; and the teacher will delight in its possibilities for classes in constellation study or appreciation of astronomy.

GEORGE V. PLACHY
Amateur Astronomers
Association, N.Y.C.

NEW BOOKS RECEIVED

FROM COPERNICUS TO EINSTEIN, *Hans Reichenbach, translated by Ralph B. Winn.* 1942, *The Philosophical Library.* 123 pp. $2.00.

A short history of the ideas and work of the men who provided the background for the theory of relativity, and a discussion for the layman of Einstein's special and general theories.

AIR NAVIGATION, Part I and II, *Edited by E. Molloy.* 1942, *Chemical Publishing.* 128 pp. and 132 pp. $2.50 each.

Volumes 22 and 23 respectively of the Aeroplane Maintenance and Operation Series, Part I deals with the various principles of navigation, and a section on meteorology, and Part II discusses the operation and uses of instruments for modern air navigation.

ESSENTIALS OF ASTRONOMY, *John Charles Duncan.* 1942, *Harper.* 181 pp. $1.85.

This short text should be invaluable for home study and for classroom use in amateur societies. The arrangement of the book, and its many diagrams and supplementary tables will make it useful for reference.

SEA AND AIR NAVIGATION, *W. M. Smart,* 1941, *Oxford.* 48 pp. 70 cents.

The Halley lecture for 1941, delivered by the Regius professor of astronomy in the University of Glasgow, gives a historical background and a discussion of modern principles of the vital subject of navigation.

NEWS NOTES

BY DORRIT HOFFLEIT

CATACLYSM AND EVOLUTION

Can astronomical catastrophes account for the abrupt changes in historical geology and the gaps found in the genealogy of life forms? This is the subject discussed by Dr. H. H. Nininger in a *Contribution* of the Society for Research on Meteorites.

Suppose a little planetoid like Hermes, having a diameter of about 2,000 feet and a mass of a few billion tons, suddenly struck the earth—instead of missing by only a few hundred thousand miles as it did on its last passing visit in 1937. Probably many hundreds of bodies like Hermes have come within the earth's distance of the sun; the suggestion of an encounter in geological time is not altogether extravagant. The force of the impact would have produced an explosion of four times the violence of the same tonnage of nitroglycerin. Scarcely any living things on the same continent could have survived. If the body had fallen in the ocean, tidal waves might have proved as disastrous to life on the adjoining continents as if the blow had struck on land.

Yet the scar from such a collision would now be concealed by water, jungle, desert or arctic wastes. If lunar craters can indicate the sizes of bodies that the earth has encountered in the past, Dr. Nininger states, great changes in shore lines, elevation and depression of large areas, extension or withdrawal of seas, as well as widespread and protracted climatic changes resulting from the heat of impact might have occurred. Such changes would have necessitated faunal and floral readjustments; species would have disappeared abruptly, eventually to become replaced by others. In general, from the collision of an asteroid with the earth, one should expect just such sudden breaks as the geologists, evolutionists, and paleontologists actually do find among the natural records in rock formations.

PERIOD-LUMINOSITY

In 1912, Henrietta Leavitt at Harvard first pointed out the relation between the periods and the apparent brightnesses of 25 Cepheid variables in the Small Magellanic Cloud. Since all the stars in the Cloud are at essentially the same distance, the relation would hold equally well between the periods and the *real* brightnesses.

This proved an important correlation in the determination of galactic and extragalactic distances. Although the original empirical relation has served admirably in extending our knowledge of space, there is still room for improvement in its accuracy. Hence the variable stars in both Magellanic Clouds have been under almost continuous investigation at Harvard.

In a recent contribution to the *Proceedings* of the National Academy of Sciences, Dr. Harlow Shapley, Virginia McKibben, and Richard Craig report on 564 Cepheid variables in the Small Magellanic Cloud whose periods have now been determined. Various possible causes for the scattering of points about the mean period-luminosity curve are discussed: the thickness of the Cloud, possible real differences in the luminosities of stars with the same period, obstruction of starlight, as well as photographic, observational, and computational difficulties. At present, there is no reason for a revision of the previously adopted relation. Space absorption within the Cloud itself is found to be inappreciable, except within a few well-recognized bright and dark patches. Absorption between us and the Cloud as a whole, however, ascertained through a search for distant faint galaxies in the general direction of the Cloud, amounts to one third of a magnitude.

A TENTH PLANET?

According to Science Service, Dr. R. S. Richardson, of Mt. Wilson, predicts a 10th planet for the solar system. The hunt should be centered near R.A.16h, Dec.—20° (near Beta Scorpii).

Dr. Richardson was investigating why Comet Halley was three days late at the time of its 1910 return. Pluto, at first suspected of having detained the visitor, cannot have been the culprit. If anything, Pluto would have hastened rather than delayed the comet. Another planet, the size of Pluto or the earth, grazing the aphelion of the comet's orbit by about nine million miles, would account for the comet's behavior. A larger body at a greater distance would have been equally effective, but it is believed that the planet must be small to have escaped previous notice. If it were as bright as magnitude 16.5, it seems probable that Clyde Tombaugh would have discovered it during his systematic planet-search at Flagstaff.

ARTHUR BAMBRIDGE WYSE

On June 9th, Dr. A. B. Wyse, on leave of absence from the Lick Observatory for defense activities, met death when two blimps collided in mid-air off the coast of New Jersey.

Born in Iowa in 1909, Dr. Wyse received his A.B. degree from Wooster in 1929 and his Ph.D. from Michigan in 1934. Since 1935, he has been assistant astronomer at Lick. His contributions to astronomy include investigations of eclipsing binaries, novae, and gaseous nebulae. The latest issue of the *Astrophysical Journal* contains a 30-page analysis, "The Spectra of Ten Gaseous Nebulae," in which he presents additional evidence for the existence of metallic elements in the nebulae and confirms previous conclusions by Bowen and himself concerning the relative abundances of various chemical elements in such nebulae. He showed that all the gaseous nebulae are closely similar in chemical composition, differences in their spectra being attributable mainly to differences in physical conditions.

The care and thoroughness evident in this last published paper by Wyse demonstrate impressively the capability of its author. In his premature death we have lost one of the most promising of the younger astronomers.

HONORARY DEGREE

At its Commencement exercises on May 24th, Bates College conferred the degree of Doctor of Letters on Dr. Harlow Shapley, director of Harvard College Observatory.

OBSERVER'S PAGE

All times mentioned on the Observer's Page are Eastern War Time.

VISUAL DOUBLE-STAR OBSERVATIONS—II

IN the list of double stars printed here last month, angular separations of the components ranged from 1½ to 38 seconds of arc. An observer fortunate enough to have inspected all of these double stars may have found some which his telescope would not resolve or "split." It is well to know the *resolving power* of your telescope, both theoretical and under actual observing conditions.

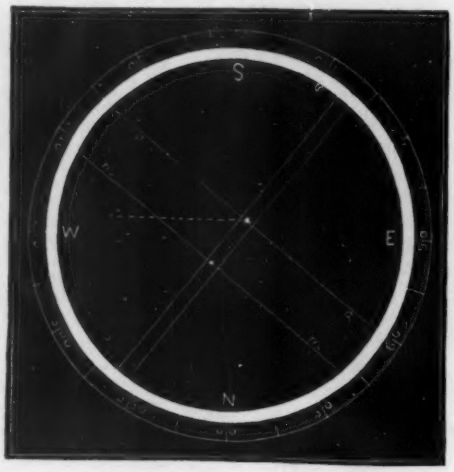
As most telescope users know, a star appears in the field of view as a disk instead of a point of light. This is sometimes called the "spurious" disk, and it is produced by the optical phenomenon of diffraction Theoretically, the angular diameter of this disk is given by $d = 4''.56/a$, where a is the aperture of the objective in inches. Thus, for a 1-inch telescope, the spurious disk is about 4½ seconds of arc in diameter; for a 3-inch glass it is 1".5; for a 6-inch glass, 0".76. For the 82-inch McDonald telescope it is 0".056, and in a recent letter to Harvard, Dr. G. P. Kuiper reports it to be "interesting and fascinating to have a spurious disk of only 0".06" for micrometer work with the 82-inch.

However, for amateur observing many other factors enter the picture. They include the quality of the telescope objective, whether it is reflector or refractor (bright stars appear multi-colored and consequently large in a refractor), the condition of the atmosphere, the magnitudes, colors, and relative brightnesses of the stars in the double being observed, and the "personal equation" of the observer. In general, very high magnifying power will not help split a double star. The average unaided eye has a limit of resolution of about 90 seconds of arc, so in a 1-inch telescope, a magnifying power of 20 should suffice under ideal conditions—the usual maximum is stated as not over 50X for each inch of aperture.

Using known double stars, preferably of wide separation, it should not take long for you to determine the size of the field of view of your instrument using different magnifications, after which unknown separations can be estimated. (Timing the drift of a star near the celestial equator is another method of determining size of field.)

In some visual double stars of comparatively short periods, such as Sirius (50 years), the separation changes noticeably in a few years, and it is in these cases that a change in position angle may be noticed by the amateur who carries his observations and records over several years. However, in most visual doubles, the distances from us are too great or the motion too slow for observation of a change in position angle in a short time.

An easy familiarity with the significance of *position angle* is essential for double-star observers, particularly where the companion star is faint and the separation small. Position angle is measured from north through east, which may be best understood by comparing the field of view of your (inverting) telescope to the face of a clock. The center of the dial corresponds to the "A" star or primary (generally the brightest); then 12 o'clock is south, and 6 o'clock is north; 3 o'clock is east, and 9 o'clock is west. Since position angle is measured counterclockwise, 3 o'clock will be at 90°, 12 o'clock at 180°, and 9 o'clock at 270°. So a star whose position angle is 150° is in the direction of 1 o'clock from its primary, which is considered in the center of the field.



A double star in the inverted field of view of a position micrometer. The fixed and movable wires (a and m) are set on the component stars to measure their distance apart. The parallel wires indicate position angle, which is here about 320°. The arrow shows the direction in which the star drifts when the driving clock is stopped; therefore this is west. From "Astronomy," by Russell, Dugan, and Stewart.

One of the most difficult binaries for a small telescope is ε Canis Majoris. The magnitude of the primary, 1.63, and its spectral class, *B*1, make it a glaringly brilliant object. The 9th-magnitude companion seven seconds away is pretty dim in comparison, but knowing its position angle, 160°, the beginner can find it if he has a little patience. A line from Sirius through the primary and extended will be at an angle of 160°. I suggest the use of this method for determining position angles by drawing similar lines on star charts when it is difficult to locate the companion star.

OCCULTATIONS—JULY, 1942

Local station, lat. 40° 48'.6, long. 4h 55.8m west.

Date	*Mag.*	*Name*	*Immersion*	*P.**	*Emersion*	*P.**
July 4	5.2	29 Piscium	1:10.4 a.m.	108°	2:01 a.m.	210°
6	4.7	ν Piscium	2:45.5 a.m.	88°	3:48.9 a.m.	227°
22	4.0	γ Librae	10:28.6 p.m.	72°	11:32.2 p.m.	315°
26	6.5	130 B Sagittarii	0:46.6 a.m.	81°	2:00 a.m.	267°

* P is the position angle of the point of contact on the moon's disk measured eastward from the north point.

BY JESSE A. FITZPATRICK

In my article on "Observing with Binoculars—II" in The SKY, June, 1941, I mentioned the classification of stars according to color. For those who may not have this reference at hand, the following list shows the principal spectral classes with the color and surface temperature in each group:

Spectral Class	*Color*	*Temperature (Fahrenheit)*
O	Blue	Above 41,000°
*B*0 to *B*9	Blue to blue-white	41,000° — 20,000°
*A*0 to *A*9	White	20,000° — 13,000°
*F*0 to *F*9	Pale yellow	13,000° — 11,000°
*G*0 to *G*9	Yellow	11,000° — 9,000°
*K*0 to *K*9	Orange	9,000° — 6,000°
*M*0 to *M*9	Red	6,000° — 5,400°

Some very capable observers profess to see other colors than those listed here, principally green, gray, lilac and lavendar. I must admit I have not seen any such colors and am satisfied to adhere to the ones which I believe are generally accepted. Frequently, the contrast of colors in a binary is very striking; for instance, the *K*0-*A*0 combination of γ Andromedae. Observing double-star colors is not only interesting but instructive, and from them can be learned the surface temperatures of the stars.

There are eight binary systems which I consider so fine as to be spectacular. The components in each case are of about the same brightness (all less than 5th magnitude) and the maximum separation of any pair is 10 seconds. These eight stars are: γ Arietis; θ Eridani; ζ Orionis; α Geminorum; κ Puppis; γ Leonis; γ Virginis; and ζ Aquarii. Further details regarding these doubles will be given when they are listed in their proper order.

ANSWERS TO DO YOU KNOW?

(Questions on page 8)

I. 1, c; 2, d; 3, c; 4, d; 5, c; 6, c; 7, b; 8, d.

II. a. 7,926 is the equatorial diameter of the earth in miles.
b. 88 is the number of recognized constellations; also, Mercury's sidereal period in days.
c. 1° 35′ is the inclination of the ecliptic to the invariable plane of the solar system.
d. −273° is absolute zero on the centigrade scale.
e. 186,271 is the velocity of light in miles per second.
f. 3.258 is the number of light-years in a parsec.

III. 1. The total of gravitational forces in any direction would be infinite, and the law therefore indeterminate.
2. The principal force is gravitational, and will be about 1/500 that at the equator on the surface (10^{-3} the distance, 10^{-9} the effective volume, about twice the density). The centrifugal force is much less, being 10^{-3} times that at the equator on the surface, where it is 1/289 surface gravity.

THE PLANETS IN JULY

Early morning risers on the 4th of July will have an opportunity to see *Venus* and *Saturn* separated by approximately four minutes of arc. The actual conjunction in right ascension will have occurred at 7:00 p.m. the previous evening, when the planets are not visible, but there will be very little change in their relative positions in the interval of a few hours. Venus, at magnitude −3.4, will outshine Saturn, magnitude +0.4, to such an extent that at this close distance the latter will be scarcely visible to the unaided eye. Binoculars, however, will clearly separate them. The planets will rise two and one half hours before the sun.

One hour east of Venus and Saturn, the planet *Mercury*, magnitude +0.7, will rise in the long early July dawn, but atmospheric conditions must be perfect for it to be seen. Two mornings later, the planet will reach its greatest elongation west, 21° 23′, when it will be slightly better placed for observation. On that date, the separation between Venus and Saturn will be a little more than two degrees.

Jupiter at this time will be about one hour behind Mercury, but too close to the sun to be seen. By the end of July, its separation of nearly two hours from the sun and its favorable position on the ecliptic, 4°.5 north of the sun, will place it well for early morning observation.

Uranus will also be in the picture on the morning of July 4th, but it will require binoculars or a telescope. Its position will be five degrees west and one degree north of Saturn.

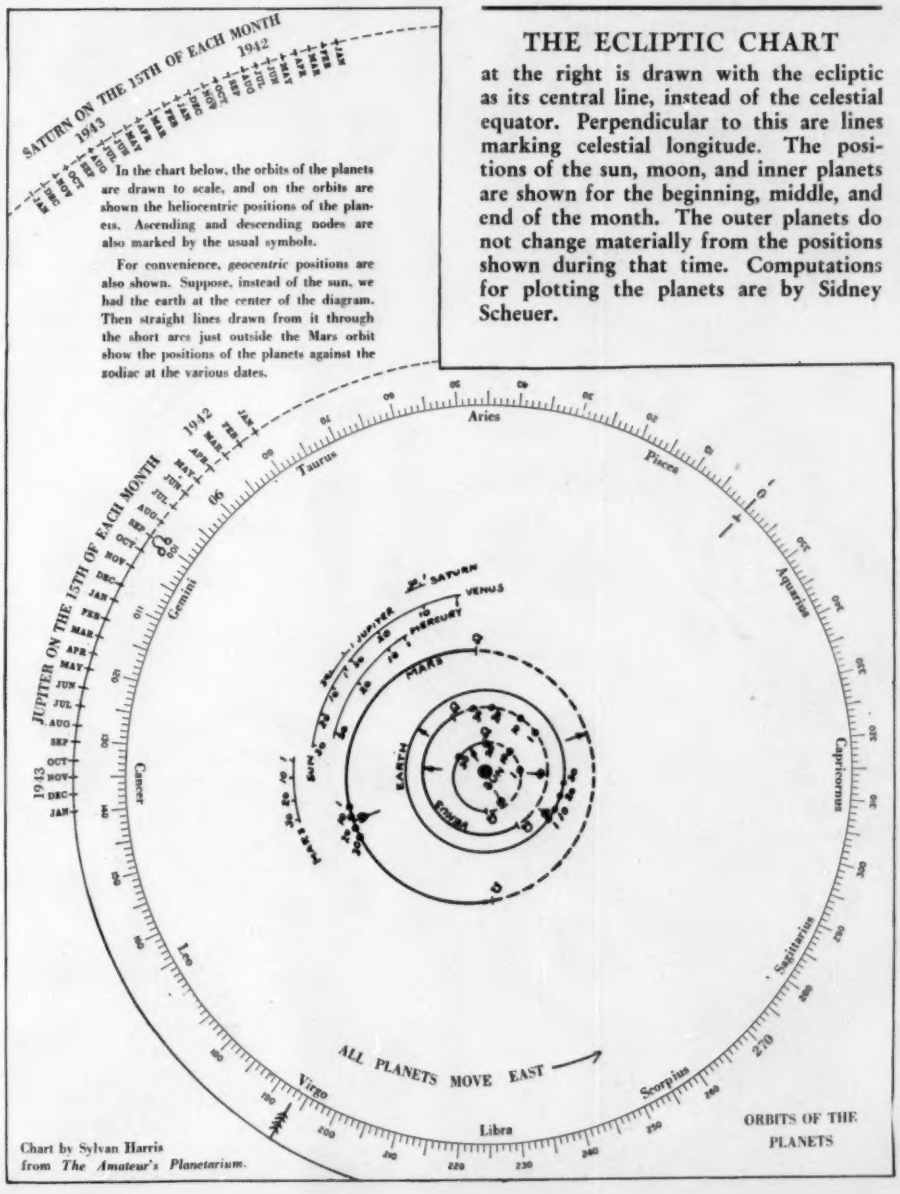
Mars will be in the evening sky through the month, but its magnitude, +2.0, will make it too faint an object for special interest.

Neptune, having resumed its progressive motion, will arrive, in the middle of the month, at about its position of May 15th as shown in the diagram of its path in the February issue, but a little more than three minutes south of its retrograde path.

The earth will reach aphelion at 8:00 p.m., July 5th, 94,555,000 miles from the sun.

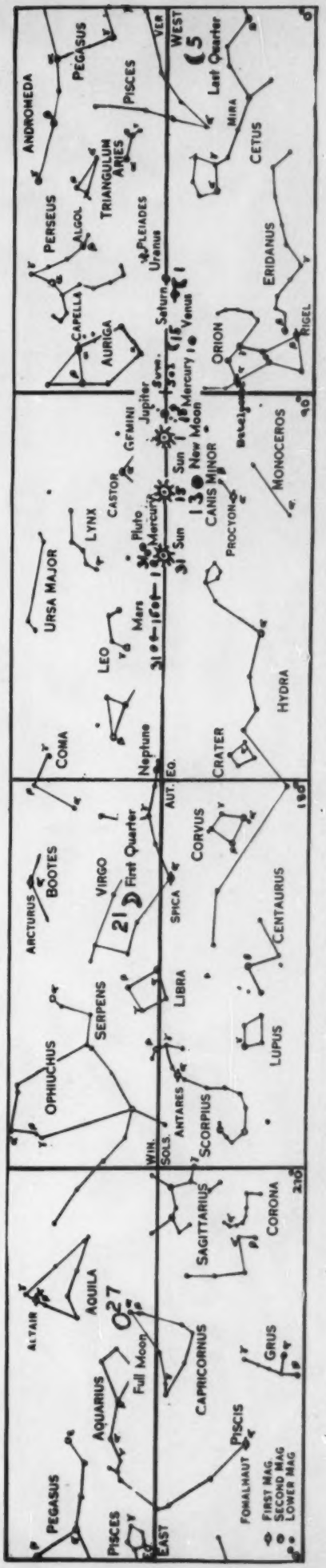
PHASES OF THE MOON

Last quarter	July 5, 4:58 a.m.
New moon	July 13, 8:03 a.m.
First quarter	July 21, 1:13 a.m.
Full moon	July 27, 3:14 p.m.


SATURN ON THE 15TH OF EACH MONTH
1942
1943
In the chart below, the orbits of the planets are drawn to scale, and on the orbits are shown the heliocentric positions of the planets. Ascending and descending nodes are also marked by the usual symbols.
For convenience, geocentric positions are also shown. Suppose, instead of the sun, we had the earth at the center of the diagram. Then straight lines drawn from it through the short arcs just outside the Mars orbit show the positions of the planets against the zodiac at the various dates.
JUPITER ON THE 15TH OF EACH MONTH
Aries
Taurus
Gemini
Cancer
Leo
Virgo
Libra
Scorpius
Sagittarius
Capricornus
Aquarius
Pisces
SATURN
VENUS
JUPITER
MERCURY
MARS
EARTH
SUN
ALL PLANETS MOVE EAST
ORBITS OF THE PLANETS
Chart by Sylvan Harris
from The Amateur's Planetarium.

THE ECLIPTIC CHART

at the right is drawn with the ecliptic as its central line, instead of the celestial equator. Perpendicular to this are lines marking celestial longitude. The positions of the sun, moon, and inner planets are shown for the beginning, middle, and end of the month. The outer planets do not change materially from the positions shown during that time. Computations for plotting the planets are by Sidney Scheuer.



THE APPARENT POSITIONS IN THE HEAVENS OF THE SUN, MOON, AND PLANETS.

The Starry Heavens in July

By Leland S. Copeland

SCORPIUS, most beautiful constellation of summer, is at its best in mid-July at 10 p.m., War Time. Its red heart, Antares, one of the largest stars, is then almost due south. Other groups on or near the meridian are Draco, Corona Borealis, Hercules, and Ophiuchus.

Homer and Old Testament authors spoke of Orion, the Pleiades, and the Bear. Why did they omit the Scorpion? How could they have missed a sight so conspicuous and resplendent?

In the east, Pegasus has tossed his head and feet above the horizon. Preceding him are Cygnus and Lyra, Aquila, Sagitta, and Delphinus. Note the shaft of the Eagle, made by Altair and its neighbors, β and γ. Lines drawn through this shaft, Sagitta, and the chief stars of Delphinus, form a triangle with the corners missing.

Sagittarius glitters in the southeast near the heart of our universe. Most noticeable details are the bow and arrow (λ, δ, ε, and γ) and the little Milk Dipper, the handle of which penetrates the great Sagittarius starcloud.

July is ideal for observing globular clusters. Of the 94 known globulars, one third are in or near Sagittarius. Five can be glimpsed with unaided vision or an opera glass—M3 (Canes Venatici), M5 (Serpens), M13 (Hercules), M22 and M55 (Sagittarius), all of which are in the night sky of July.

In the west, the Lion is setting, with Regulus on the horizon. Leo is leading four constellations rich in galaxies—Ursa Major, Canes Venatici, Coma Berenices, and Virgo. About midway in the western sky glimmers the cluster in Coma Berenices, a sky marvel that few human beings ever notice, but one that once seen is watched for through the ensuing years.

FROM POEM TO SCIENCE

FOR nearly 2,000 years Coma Berenices waited for astronomical recognition. It was first mentioned about 250 B.C. by Callimachus, poet and grammarian, but it was not accepted officially until 1602 A.D., when it was listed among constellations in a posthumous book by Tycho Brahe.

So became permanent an honor that had been given Berenice, princess of Cyrenaica, a Greek country adjoining Egypt on the west. Cyrene, early home of Berenice, is in the Libyan zone of the present war. But for centuries it has been a silent city, with broken columns and ruined stairways.

The princess was brave as well as beautiful. When her father fled in battle, she mounted a horse, rallied the host, and repelled the enemy. This deed won the admiration of her cousin, Ptolemy Euergetes, ruler of Egypt and grandson of the half brother of Alexander the Great.

A few years after she had become queen, Berenice was married to Ptolemy. Thus Cyrenaica again became an Egyptian province. Almost at once the king was forced to war on the Seleucid Empire. His sorrowful wife vowed that if he should return unharmed, she would give her hair to the gods. After leading his army to the Euphrates, he came back triumphant. So the queen cut off her tresses and placed them in a temple of Venus.

In the classic poems only a lock or curl is mentioned. This curl vanished mysteriously; perhaps it was stolen by souvenir hunters. But Conon, court astronomer and friend of Archimedes, calmed the priests by saying, "Don't worry; the gods have placed Berenice's gift in the sky." By this stratagem the wrath of the ruler was averted, but at the expense of Leo, because the tuft of the Lion's tail had been clipped off to represent the lost lock.

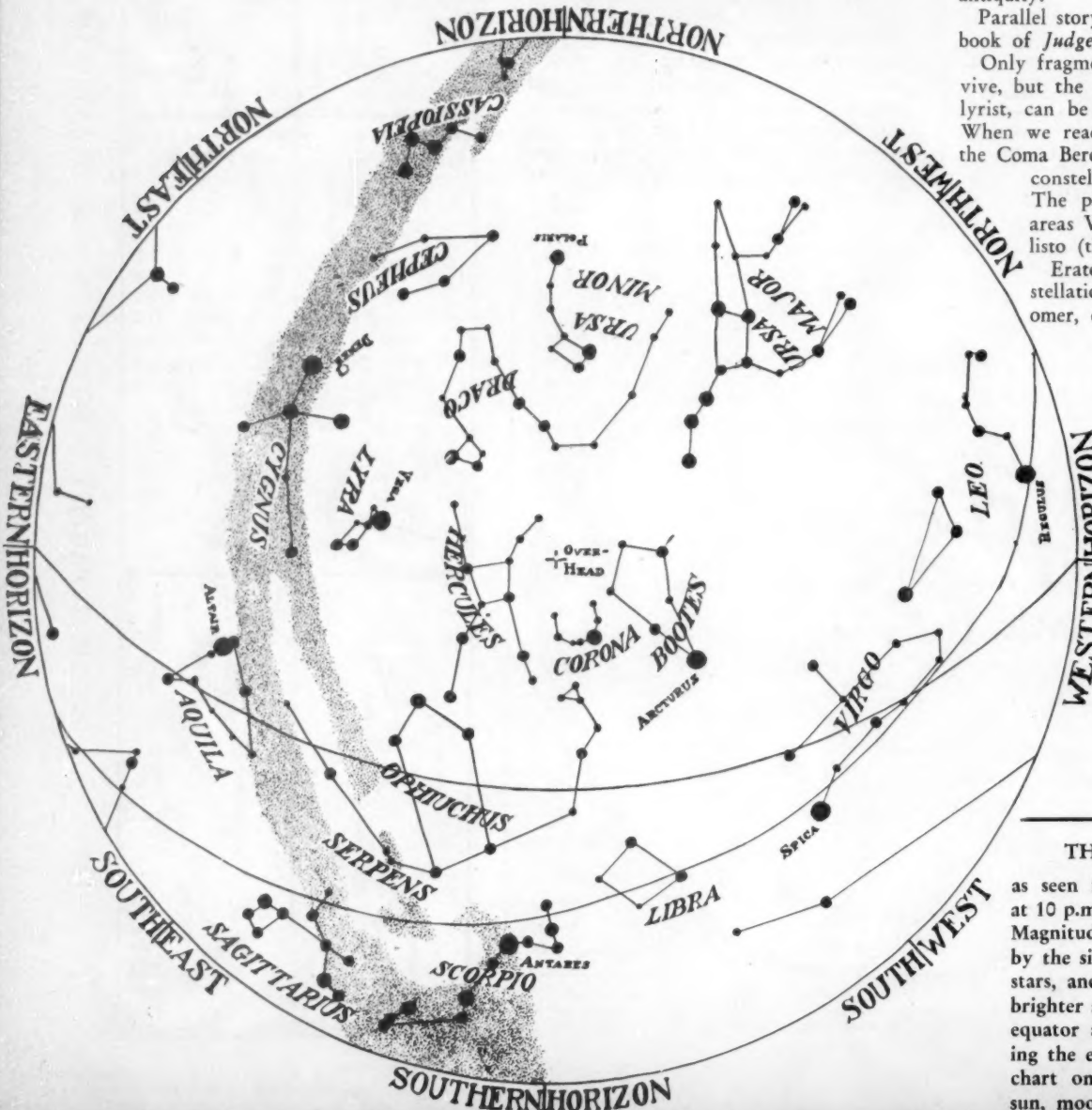
Sidelights: Eratosthenes, first to calculate the size of our planet, and Callimachus himself were natives of Cyrene, from which came Simon who bore the Cross for Christ. Conon's birthplace was Samos, which produced also Aristarchus, the Copernicus of antiquity.

Parallel story: Jephthah's daughter in the book of *Judges*.

Only fragments of the Greek poem survive, but the retelling by Catullus, Roman lyrist, can be found in our own libraries. When we read his lines, we discover that the Coma Berenices of Egypt was the same constellation that we know today. The poet mentions as neighboring areas Virgo, "the raging Lion," Callisto (the Bear), and "slow Bootes."

Eratosthenes favored the new constellation, but Ptolemy, the astronomer, omitted it. It is shown as a name, without picture, in Peter Apian's chart of 1536. But it is missing from a planisphere of the 9th or 10th century, A.D., from the drawing by Albrecht Dürer about 1515, and from Johann Bayer's atlas of 1603. In Brahe's *Historia Celeste* it appears as a headband and tresses.

Coma Berenices is a fan-shaped constellation. The pivot is at β and the arc curves from α through the famous cluster to γ. Just north of α is M53, a globular. Inside the fan is the north pole of the galaxy.



THE STARS FOR JULY

as seen from mid-northern latitudes at 10 p.m., July 7th; 9 p.m., July 23rd. Magnitudes of the stars are indicated by the sizes of the disks marking the stars, and the names of some of the brighter stars appear. The ecliptic and equator are shown, the latter touching the east-west horizon points. See chart on the "Observer's Page" for sun, moon, and planet positions.

HERE AND THERE WITH AMATEURS

This is not intended as a complete list of societies, but rather to serve as a guide for persons near these centers, and to provide information for traveling amateurs who may wish to visit other groups.

City	*Organization*	*Date*	*P.M.*	*Season*	*Meeting Place*	*Communicate with*
BOSTON	BOND AST. CLUB	1st Thu.	8:15	Oct.-June	Harvard Obs.	Homer D. Ricker, Harvard Observatory
"	A.T.M.S OF BOSTON	2nd Thu.	8:15	Sept.-June	Harvard Obs.	F. I. Noyes, 340 Warren St., Brockton, Mass.
BROOKLYN, N.Y.	ASTR. DEPT., B'KLYN INST.	Rd. Table 3rd Thu.	8:00	Oct.-April	Brooklyn Inst.	William Henry, 154 Nassau St., N.Y.C., *BA.* 7-9473
BUFFALO	A.T.M.S & OBSERVERS	1st, 3rd Fri.	8:00	Oct.-June	Mus. of Science	J. J. Davis, Museum of Science
CHATTANOOGA	BARNARD A. S.	4th Fri.	7:30	All year	Chattanooga Obs.	C. T. Jones, 1220 James Bldg., *CHat.* 6-8341
CHICAGO	BURNHAM A. S.	2nd, 4th Tue.	8:00	Sept.-June	Congress Hotel	Wm. Callum, 1435 Winona Ave.
CLEVELAND	CLEVELAND A. S.	Fri.	8:00	Sept.-June	Warner & Swasey Obs.	Mrs. Royce Parkin, The Cleveland Club
DAYTONA BEACH	D. B. STARGAZERS	Alt. Mon.	8:00	Nov.-June	500 S. Ridgewood Ave.	Rolland E. Stevens, 500 S. Ridgewood
DETROIT	DETROIT A. S.	2nd Sun	3:00	Sept.-June	Wayne U., Rm. 187	E. R. Phelps, Wayne University
"	NORTHWEST A.A.S.	1st, 3rd Tue.	8:00	Sept.-June	Redford High Sch.	A. J. Walrath, 14024 Archdale Ave.
DULUTH, MINN.	DULUTH AST. CLUB	1st, 3rd Sat.	8:00	All year	Darling Obs.	W. S. Telford, 126 N. 33rd Ave. E.
FT. WORTH	TEX. OBSERVERS	No regular meetings				Oscar E. Monnig, 1010 Morningside Dr.
GADSDEN, ALA.	ALA. A.A.	1st Thu.	7:30	All year	Ala. Power Audit.	Brent L. Harrell, 1176 *W* or 55
INDIANAPOLIS	INDIANA A.A.	1st Sun.	2:00	All year	Central Library Audit.	E. W. Johnson, 808 Peoples Bank Bldg.
JOLIET, ILL.	JOLIET A.S.	Alt. Tue.	8:00	Oct.-May	Jol. Mus. & Art Gall'y	Monica L. Price, 403 Second Ave.
LOS ANGELES	L.A.A.S.	2nd Thu.	8:15	.....	2606 W. 8th St.	Charles Ross, 2606 W. 8th St.
LOUISVILLE, KY.	L'VILLE A.S.	3rd Tue.	8:00	Sept.-May	Women's Bldg., Univ. of Louisville	Mary Eberhard, 3-102 Crescent Ct., *Taylor* 4157
MADISON, WIS.	MAD. A.S.	2nd Wed.	8:00	All year	Washburn Obs.	C. M. Huffer, Univ. of Wisconsin
MILWAUKEE	MILW. A.S.	1st Thu.	8:00	Oct.-May	Marquette U., Eng. Col.	E. A. Halbach, *Hopkins* 4748
MOLINE, ILL.	POP. AST. CLUB	2nd Tue.	7:30	All year	Sky Ridge Obs.	Carl H. Gamble, Route 1
NEW HAVEN	NEW HAVEN A.A.S.	1st Sat.	8:00	Sept.-June	Yale Obs.	F. R. Burnham, 820 Townsend Ave., 4-2618
NEW YORK	A.A.A.	1st, 3rd Wed.	8:15	Oct.-May	Amer. Mus. Nat. Hist.	G. V. Plachy, Hayden Plan., *EN.* 2-8500
" "	JUNIOR AST. CLUB	Alt. Sat.	8:00	Oct.-May	Amer. Mus. Nat. Hist.	J. B. Rothschild, Hayden Plan., *EN.* 2-8500
NORWALK, CONN.	NORWALK AST. SOC.	Last Fri.	8:00	Sept.-June	Private houses	Mrs. A. Hamilton, 4 Union Pk., 6-4297
OAKLAND, CAL.	EASTBAY A.A.	1st Sat.	8:00	Sept.-June	Chabot Obs.	Miss H. E. Neall, 6557 Whitney St.
PHILADELPHIA	A.A. OF F.I.	3rd Fri.	8:00	All year	The Franklin Inst.	Edwin F. Bailey, *Rit.* 3050
"	RITTENHOUSE A.S.	2nd Fri.	8:00	Oct.-May	The Franklin Inst.	A. C. Schock, *Rit.* 3050
PITTSBURGH	A.A.A. OF P'BURGH	2nd Fri.	8:00	Sept.-June	Buhl Planetarium	Louis E. Bier, 402 Cedarhurst
PONTIAC, MICH.	PONTIAC A.A.A.	2nd Mon.	8:00	All year	Cranbrook Inst. of Sci.	J. P. Coder, 2675 Voorheis Rd., 2-9419
PORTLAND, ME.	A.S. OF MAINE	2nd Fri.	8:00	All year	Private homes	H. M. Harris, 27 Victory Ave., S. Portland
PROVIDENCE, R.I.	SKYSCRAPERS	1st Wed.	8:00	All year	Wilson Hall, Brown U.	Ladd Obs., Brown U., *GA.* 1633
READING, PA.	READING-BERKS A.C.	2nd Thu.	8:00	Sept.-June	Albright College	Mrs. F. P. Babb, 2708 Filbert Ave.
RENO, NEV.	A.S. OF NEV.	4th Wed.	....	All year	Univ. of Nevada	G. B. Blair, University of Nevada
ROCHESTER, N.Y.	ROCH. AST. CLUB	Alt. Fri.	8:00	Oct.-May	Eastman Bldg., Univ. of Rochester	M. L. Groff, 400 University Ave.
SAN ANTONIO	SAN ANT. A.A.	3rd Mon.	8:00	All year	Le Villela	R. B. Poage, 807 Hammond Ave.
SCHENECTADY	S'TADY AST. CLUB	3rd Mon.	8:00	All year	Observatory site	C. H. Chapman, 216 Glen Ave., Scotia
SOUTH BEND, IND.	ST. JOSEPH VAL. AST.	Last Tue.	8:00	All year	928 Oak St.	Fannie Mae Chupp, 224 Seebirt Pl.
STAMFORD, CONN.	STAMFORD AST. SOC.	4th Wed.	8:00	Oct.-June	Stamford Museum	Stamford Mus., 300 Main St.
TACOMA, WASH.	TACOMA A.A.	1st Mon.	....	All year	Coll. of Puget Sound	Geo. Croston, *Gar.* 4124
WASHINGTON, D.C.	NAT'L. CAP. A.A.A.	1st Sat.	8:00	Oct.-June	U. S. Nat'l. Museum	Stephen Nagy, 104 C St., N.E., *Linc.* 9487-J
WICHITA, KANS.	WICHITA A.S.	2nd Tue.	8:00	All year	E. High Sch., Rm. 214	S. S. Whitehead, 2322 E. Douglas, 33148
YAKIMA, WASH.	YAK. AM. ASTR'MERS	2nd Tue.	7:30	All year	Y.M.C.A. Audit.	J. L. Thompson, 4 S. 10 Ave., 21455

Sky and Telescope is official publication of many of these societies.

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PLANETARIUM NOTES

Sky and Telescope is official bulletin of the Hayden Planetarium in New York City and of the Buhl Planetarium in Pittsburgh, Pa.

★ **THE BUHL PLANETARIUM** presents, *beginning July 2nd,* TELLING TOMORROW'S WEATHER.

Many people's personal contacts with some sciences are rare—but not with the science of the weather. The laboratory of the weatherman is the air we breathe, the sky above us. It has been said indeed that no other factor in life affects a person so continuously and importantly as weather. Since in wartime every man must be his own weather prophet, the Buhl Planetarium this month presents visually in its man-made sky a large number of familiar weather portents, and enables us to distinguish between the true and the false. Experiencing a variety of weather in the span of some 40 hours, visitors are shown especially the prime role played by different types of clouds in telling us what sort of weather is around the corner—the "mare's-tails" and "feather clouds," the beautiful bunchy cumulus clouds, the "curdled sky" and "mackerel sky" and others. We discover that while some of the time-honored weather adages (a few of which were being quoted as early as 4000 B.C.) are still good weather science today, others are not to be trusted.

★ **THE HAYDEN PLANETARIUM** presents *in August,* ECLIPSES, ANCIENT AND MODERN.

On the night of August 26th there will be a striking eclipse of the moon that you can see if the weather is clear. However, fair weather or foul, the whole selection of eclipses of the sun and moon can be seen in the Hayden Planetarium every day during August. Partial, total, and annular eclipses of the sun; partial and total eclipses of the moon, appulses, and so on, will be discussed in conjunction with special projection equipment, movies and stills.

In September, AUTUMN SKIES.

Today there is an increased interest in learning the stars. To identify the stars is a part of the navigator's technique. He must learn to point them out and to know their names in order to find them in his almanac list. The airplane spotter as well must know his sky. In his long lonely vigil the sky offers him something for contemplation. This month we are again studying the ancient constellations and the most up-to-date astronomical information as well. With striking photographs, the mythical figures and the Planetarium projector will show us the autumn sky.

★ SCHEDULE BUHL PLANETARIUM

Tuesdays through Fridays.....3 and 8:30 p.m.
Saturdays .....2, 3, and 8:30 p.m.
Sundays and Holidays.....3, 4, and 8:30 p.m.
(Building closed Mondays)

★ STAFF—*Director,* Arthur L. Draper; *Lecturer,* Nicholas E. Wagman; *Business Manager,* Frank S. McGary; *Public Relations,* John J. Grove; *Curator of Exhibits,* Fitz-Hugh Marshall, Jr.

★ SCHEDULE HAYDEN PLANETARIUM

Mondays through Fridays.....2, 3:30, and 8:30 p.m.
Saturdays .....11 a.m., 2, 3, 4, 5, and 8:30 p.m.
Sundays—Mutual Network Broadcast—Coast-to-Coast..9:30-10 a.m.
Sundays and Holidays.....2, 3, 4, 5, and 8:30 p.m.

★ STAFF—*Honorary Curator,* Clyde Fisher; *Curator,* William H. Barton, Jr.; *Assistant Curators,* Marian Lockwood, Robert R. Coles (on leave in Army Air Corps), John Ball, Jr.; *Staff Assistant,* Fred Raiser; *Lecturers,* Asa Tenney, Charles H. Coles.